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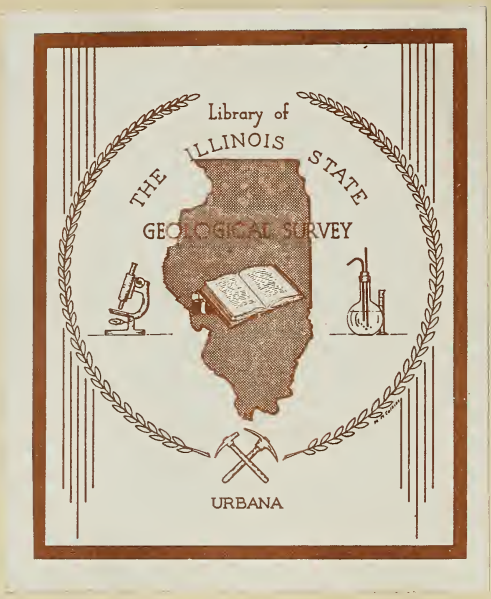


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STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
A. M. SHELTON, *Director*
DIVISION OF THE
STATE GEOLOGICAL SURVEY
M. M. LEIGHTON, *Chief*

## BULLETIN No. 50

# NATURAL-BONDED MOLDING SAND RESOURCES OF ILLINOIS

BY
M. S. LITTLEFIELD

Laboratory Tests in Cooperation with the Engineering Experiment Station, University of Illinois

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# NATURAL-BONDED MOLDING SAND RESOURCES OF ILLINOIS

BY

M. S. LITTLEFIELD

## CHAPTER I—INTRODUCTION

### State's Production

The State of Illinois, by virtue of its large number of foundries, produces a relatively large amount of molding sand. The State ranks fifth in number of foundries, and third in the production of molding sand. Table 1 shows the distribution by counties of the 496 foundries in operation in 1923.[1] The latest figures showed a total of 490[2] foundries for the State.

Table 1.—*Distribution, by counties, of foundries; producing molding sand pits; and samples collected and tested*

| County | Number of foundries | Number of producing molding sand pits | Number of samples collected and tested |
|---|---|---|---|
| Adams | 17 | 2 | 1 |
| Alexander | 4 | .. | .. |
| Bond | .. | 5 | 9 |
| Boone | 1 | .. | 1 |
| Bureau | .. | 3 | 5 |
| Cass | .. | 1 | 7 |
| Champaign | 5 | .. | .. |
| Christian | 1 | .. | .. |
| Clinton | 1 | .. | 1 |
| Coles | 3 | .. | .. |
| Cook | 219 | .. | 1 |
| De Kalb | 4 | .. | .. |
| Edgar | 2 | .. | .. |
| Fayette | .. | 4 | 7 |
| Ford | 1 | .. | .. |
| Franklin | 1 | .. | .. |
| Fulton | 2 | .. | .. |
| Gallatin | 1 | .. | 2 |
| Grundy | 2 | .. | .. |
| Hancock | .. | 1 | 2 |
| Henderson | 1 | 5 | 10 |
| Henry | 6 | 1 | 10 |
| Jackson | 2 | .. | 1 |
| Jefferson | 2 | .. | .. |
| Jo Daviess | 3 | 1 | 3 |

[1]Data furnished by C. E. Hoyt, Secretary, American Foundrymen's Association.
[2]The Foundry, p. 801, October 15, 1924.

TABLE 1.—*Distribution by counties of foundries; producing molding sand pits; and samples collected and tested—Concluded*

| County | Number of foundries | Number of producing molding sand pits | Number of samples collected and tested |
|---|---|---|---|
| Kane | 25 | 5 | 6 |
| Kankakee | 5 | .. | .. |
| Kendall | .. | .. | 1 |
| Knox | 7 | .. | .. |
| Lake | 9 | .. | .. |
| La Salle | 3 | .. | 1 |
| Lawrence | 1 | .. | 1 |
| Lee | 1 | .. | .. |
| Livingston | 2 | .. | .. |
| Logan | 2 | .. | .. |
| McDonough | 2 | .. | .. |
| McHenry | 3 | 1 | 3 |
| McLean | 5 | .. | .. |
| Macon | 11 | .. | .. |
| Madison | 9 | 2 | 3 |
| Marion | 1 | .. | .. |
| Marshall | .. | .. | 1 |
| Mason | 2 | .. | .. |
| Massac | 1 | .. | .. |
| Montgomery | 2 | .. | .. |
| Morgan | 1 | .. | .. |
| Ogle | 1 | .. | 3 |
| Peoria | 15 | 1 | 4 |
| Perry | 2 | .. | .. |
| Pope | .. | .. | 6 |
| Pulaski | .. | .. | 1 |
| Randolph | .. | .. | 1 |
| Rock Island | 24 | 3 | 8 |
| Saline | 1 | .. | .. |
| Sangamon | 9 | .. | 1 |
| Shelby | .. | .. | 1 |
| St. Clair | 21 | 1 | 1 |
| Stephenson | 7 | .. | .. |
| Tazewell | 1 | .. | 1 |
| Vermilion | 7 | .. | .. |
| Warren | 3 | .. | .. |
| White | .. | .. | 3 |
| Whiteside | 7 | 1 | 4 |
| Will | 8 | 4 | 6 |
| Winnebago | 20 | 1 | 5 |

Table 2 gives the production of molding sand in Illinois from 1904 to 1922.

TABLE 2.—*Production and value of molding sand in Illinois, 1904-1922*

| Year | Molding Sand | | |
|---|---|---|---|
| | Quantity | Value | Average price per ton |
| | *Short tons* | | |
| 1904 | 574,488 | $363,090 | $0.63 |
| 1905 | 336,247 | 189,423 | .56 |
| 1906 | 372,307 | 216,087 | .58 |
| 1907 | 372,884 | 237,149 | .64 |
| 1908 | 143,080 | 86,213 | .60 |
| 1909 | 288,518 | 143,922 | .50 |
| 1910 | 407,232 | 215,742 | .53 |
| 1911 | 237,359 | 120,690 | .51 |
| 1912 | 540,728 | 268,521 | .50 |
| 1913 | 404,717 | 181,794 | .45 |
| 1914 | 347,543 | 200,011 | .58 |
| 1915 | 383,185 | 195,992 | .51 |
| 1916 | 632,529 | 313,219 | .49 |
| 1917 | 703,208 | 412,626 | .59 |
| 1918 | 885,617 | 658,205 | .74 |
| 1919 | 482,219 | 338,893 | .70 |
| 1920 | 763,590 | 915,190 | 1.20 |
| 1921 | 309,180 | 352,857 | 1.14 |
| 1922 | 654,761 | 606,779 | .93 |

The high rank of the State as a producer of molding sand is due to the intensive development of the silica sand deposits (see Table 3), the production of which more than fills the State's needs for steel molding sand. The totals of natural-bonded sand are insufficient for the needs of the State's foundries.

TABLE 3.—*Production of molding sand in Illinois by variety, 1922-1923*

| Year | Steel sand | Natural-bonded sands | Total | Natural-bonded sands |
|---|---|---|---|---|
| | *Tons* | *Tons* | *Tons* | *Per cent* |
| 1922 | 546,765 | 107,996 | 654,761 | 16.5 |
| 1923 | 647,963 | 150,720 | 798,683 | 18.9 |

For the foundries visited in Chicago, more than 50 per cent of the sand was obtained outside Illinois, and for those located elsewhere in the State, approximately 10 per cent. Of the State's 490 foundries, 200 are located in Chicago. If the percentages given above hold true, about

one-fourth of the natural-bonded molding sand used within Illinois is obtained from other states. It is probable that the greater part of the sand shipped in is fine sand.

## Available Information

Practically no information is available on the molding sand deposits of the State. Published reports on areal geology contain few references to molding sand deposits as such, but the geological data in these reports were very useful in the location and study of the molding sand deposits.

## Molding Sand Investigation Program

The American Foundrymen's Association, through the Joint Committee on Molding Sand Research, suggested to State Geologists the benefit to be derived from a field and laboratory investigation of the molding sands of their respective states. Several states, among them Illinois, are aiding in the plan, which ultimately will yield information on the quantity and quality of the molding sands available in the United States.

## Purpose of the Report

This report contains the results of the field and laboratory investigation of the molding sand resources of Illinois. A preliminary report, containing locations of deposits and Standard Test data, was issued in April, 1925, in order to make such data available as soon as possible. The present report has three functions: (1) to describe the occurrence of the State's resources of natural-bonded molding sand; (2) to describe the physical properties of Illinois natural-bonded molding sands; and (3) to present general conclusions as to the relation of physical properties of natural-bonded molding sands to their origin. These conclusions are based upon both field and laboratory work. The functions of this report do not include specific correlation between Standard Test data and foundry use. The problems involved in the selection and control of foundry sands are essentially deeper than a careful survey of the available foundry literature would indicate. Recognizing the truth of this statement, the ultimate object of this report is to translate the origin and physical properties of Illinois natural-bonded molding sand into the language of Standard Test data, from which they can be translated into terms of foundry use to suit individual foundry needs.

## Methods of Investigation

### Field work

Field work was carried on from June 18 to September 15, 1923, by the State Geological Survey. The party travelled by auto, and samples were shipped by express to headquarters.

#### Area covered

Of the 102 counties of the State, 85 were studied, those omitted being counties from which no production has been reported and whose geological conditions indicate that they are barren territory.

In order to become familiar with the various phases of the problem, the party visited producing pits and foundries, and studied samples of sands in use. During the course of the work, forty foundries, located in Chicago, Peoria, Moline, East Moline, Rock Island, East St. Louis, Belleville, Quincy, Rockford, and other cities, were visited. All known producing deposits were examined and areas which were known to be favorable geologically were searched for new deposits.

### ESTIMATION OF EXTENT OF DEPOSITS

The estimation of the extent of deposits was necessarily approximate, as a detailed determination of the thickness and extent of each deposit was out of the question in an investigation including the entire State. In the estimates of tonnage of sand for each deposit (see Chapter VI), two figures are given; the first is a conservative estimate of sand actually seen, and the second, probable tonnage of the whole deposit. These estimates do not represent the total molding sand resources of the various counties, for there are doubtless deposits which were not seen.

### SAMPLING METHODS

Samples of molding sand were obtained from three general sources—from the foundry bins, from pit sections or partially loaded cars at the pits, and from dug sections of undeveloped outcrops. Samples taken from cars were selected from various parts of the car and carefully mixed. These included produced grades. A few produced grades were taken from the pit section, care being taken to include exactly that part of the section being dug. Most samples mixed from pit sections are called possible grades, as there is sufficient sand in position to produce a like grade. There are, however, some types of deposits which are so variable that large quantities of a given grade are difficult to obtain.

The producers' grade classification is given in Tables 30 and 31 only in case the producer definitely stated that the grade was standard. Also it cannot be assumed that all produced grades or possible grades will conform exactly with the test results given in this report. In order that sands can be bought on a basis of standard tests, they must be produced by controlled methods, but even then, purchasing plants must observe a reasonable degree of tolerance.

### LABORATORY WORK

The testing of the samples collected during the summer of 1923 was done cooperatively during the summer of 1924 by the Engineering Experiment Station of the University of Illinois and the Illinois Geological Survey, in the foundry laboratory of the department of Mechanical Engineering. The equipment in this laboratory is as specified in the Standard Test Procedures recommended by the American Foundrymen's Association and the results are therefore comparable with the results of other organizations using the standardized tests. In addition, base permeability tests, with the clay removed, were made on all the sands; and durability tests which gave the percentage of a bond strength

lost by heating for two hours at a temperature of 600 degrees Fahr., were made on 48 sands.

A total of 137 samples was collected and tested, 55 from producing pits, 42 from new deposits, and 40 from foundries (see Tables 1, 30, and 31). The 40 samples from foundries included 24 Illinois sands and 16 "foreign" sands. All known producing pits in Illinois were visited. Twenty-nine new deposits of commercial promise were found and sampled (see Table 32).

## Resources of Natural-bonded Molding Sand

The resources of commercial natural-bonded molding sand are estimated to approximate at least 6,000,000 tons, exclusive of the sands of the St. Peter formation, and of the limy yellow silts, known geologically as loess, in the western part of the State. There are several million tons available in the Wabash valley at points three to five miles from railroads which were not sampled nor included in the estimates as being commercial.

The sand resources of the State may be roughly divided into two classes:—(a) the fine, and (b) the medium and coarse sands. The latter are abundant and probably will furnish a sufficient supply for many years. The fine sands, of usable quality, are not so abundant. The loess, or calcareous yellow silt, which is found in abundance along the bluffs of Mississippi River and for some miles to the east, does not seem worthy of consideration in competition with lime-free sands of the same texture. It is used for some purposes, and in view of its abundance and uniformity, it is regretable that it cannot be further utilized.

## Status of the Illinois Sand Producer

The use of special equipment to facilitate production is confined entirely to companies engaged in full-time production of molding sand. In endeavoring to produce sands of good quality, they are led to some study of foundry needs, and thereby gain an understanding of the physical properties of sand which enables them to produce it more intelligently.

The part-time producer, whose sand is marketed by a foundry supply concern, has little personal contact with the foundry. The production of molding sand, no simple task at best, requires him to make selections and judgments which are, through no fault of his own, beyond his knowledge. It seems entirely probable that the gradual fall into disfavor of the sand from any one district may be due to such a producer's working into a part of a deposit which contains sand of poorer quality than his original output. The fact that this sand is bad may give rise to prejudice against the whole district.

The statement that the molding sand of a given district is worked out and that good sand can no longer be obtained from it, can hardly apply in Illinois in the sense that the deposits are entirely worked out. Where such a statement is made, there is the possibility that the development of molding sand deposits may have caused landowners to charge unduly high prices for sand-development rights, or that the landowners felt that agricultural land might be injured by sand development.

To the impartial observer it would seem that the usual attitude of the foundrymen and the sand producer towards one another is not indicative of the existence of a high degree of cooperation. Each is confronted by problems, the means of solution of which are largely in the hands of the other; and not until there is widespread cooperation of foundrymen conversant with molding sand production and sand producers familiar with foundry practice, will these problems be solved in a manner in accord with the field conservation and the most economical foundry use of molding sands.

## Acknowledgments

The success of this scientific study has been dependent in large measure on the interest and cooperation of the molding sand producers and foundrymen of the State. Attention given by the Chicago Foundrymen's Association and the Quad City Foundrymen's Association enabled the visitation of more plants than would have been otherwise possible.

Dr. M. M. Leighton, Chief of the State Geological Survey, was in constant touch with the work, and his detailed knowledge of the glacial deposits of northern Illinois made possible a systematic survey of difficult areas; Mr. L. F. Athy, of the University of Chicago, ably assisted in the field work; Mr. B. W. Benedict, Manager of the Shop Laboratory, provided full laboratory facilities; Mr. R. E. Kennedy, assistant secretary of the American Foundrymen's Association, gave helpful advice during both field and laboratory work; Professor C. W. Parmelee, Head of the Department of Ceramics, extended aid in pursuing experimental work on heat tests; Mr. W. M. Saunders made dye-adsorption tests on 135 sands; Mr. H. W. Dietert, Sand Technologist of the United States Radiator Corporation, Detroit, suggested practical test procedures from his own experience; and in the laboratory, Mr. R. S. Datta and Mr. B. F. Nordmann of the University of Illinois were helpful assistants by reason of their scientific interest.

# CHAPTER II—PHYSICAL PROPERTIES OF NATURAL-BONDED MOLDING SANDS

## Definition of Molding Sand

The commonly given definitions of molding sand state the characteristics of the ideal molding sand, a material seldom encountered in nature. A definition from the standpoint of use will include many molding sands which are far from the ideal, but which are profitably used. Hence, molding sand may be defined as any material which, when moist, can be formed into a mold from which usable metal castings may be made. This includes both artificially bonded molding sands, which are artificial mixtures of sand and clay, and natural-bonded molding sands, which are mixtures of sand and clay as they occur in nature.

## Importance of Sampling Methods

All natural-bonded molding sands possess in common a number of physical properties. The suitability of a natural-bonded molding sand for a specific kind of work is determined by the combination of various degrees of the different physical properties. When the physical properties of a sand are to be determined in the laboratory, it is imperative to obtain as representative a sample of the deposit as possible. In some cases it is impossible to obtain a sample which is adequately representative of a deposit of several acres' extent. It is, however, entirely possible to obtain a sample typical of the molding sand which could be produced from the deposit for a considerable time; and by examination of auger borings or of such natural exposures as may be found, it is further possible to estimate with fair accuracy the character of the molding sand throughout the deposit.

In sampling producing pits or natural exposures, vertical channels a few inches deep and as wide as the shovel were cut through the total workable section at several points along the exposure. The sand thus obtained was shoveled to a large piece of canvas and the gross sample halved and quartered as recommended by the Joint Committee on Molding Sand Research.[1]

Where a vertical section of a deposit was not exposed it was necessary to dig pits to obtain samples. Such deposits were discovered by boring with the hand auger, and pits put through the workable thickness of sand. Though samples obtained in that way are not as representative as those taken from the face of a working pit, they may have considerable value in some instances.

## Fineness

Fineness is the most important single property of molding sand because of the fact that the degree of other important physical properties

[1]Tentatively adopted methods of tests and resumé of activities of the Joint Committee on Molding Sand Research: American Foundrymen's Association bulletin, June 1, 1924 (Edition corrected August 1, 1924).

is governed by it to considerable extent. The term fineness may be used in two ways, both having to do with the size of the constituent grains and particles of molding sand:

### DEFINITION

#### RELATIVE FINENESS

1. For those variations of fineness of molding sands that may be readily determined by touch, the term "relative fineness" is used. A coarse sand, when molded, gives a surface of much coarser texture than does a fine sand, and the resulting casting will have a rougher surface than one poured in a fine sand.

#### SIZE-GRADE DISTRIBUTION

2. The degree of sorting, or the size grade distribution of the constituent grains and particles, may differ greatly in sands which seem to the eye and hand to be of the same relative degree of fineness. Such variation in the proportions of grains or particles of the various sizes affects the bond strength and permeability to a considerable extent, but in itself does not affect the suitability of a molding sand for a given use. Because of this factor, which causes sands which are alike in external appearance to behave very differently under use, the belief has arisen generally that every molding sand is a law unto itself and that scientific methods of control of molding sands are difficult of application.

All fineness test data included in this report were obtained by use of the Standard Fineness Test,[1] which is as follows:

### STANDARD FINENESS TEST

50 grams of molding sand, dried for at least 1 hour at a temperature which shall not be lower than 105 degrees Centigrade nor higher than 110 degrees Centigrade, are put into a 1-quart milk bottle[2] or preserving jar, smooth on the inside, with no sharp shoulders in the neck, to permit the sand to be easily removed with a small stream of water. 475 cubic centimeters of water and 25 cubic centimeters of a standard solution of sodium hydroxide (made by dissolving 10 grams of sodium hydroxide in 1000 cubic centimeters of water) are added, and the bottle or jar is covered and securely sealed. In using a preserving jar, instead of the usual rubber ring, a rubber disc is employed, which fits into the inside of the glass cover. The receptacle is then placed in a shaking machine, making about 60 revolutions per minute, in such a manner as to allow it to be up-ended at each revolution. At the end of 1 hour the receptacle is removed, the cover is unsealed, and the sand adhering to the cover is washed into the receptacle. The receptacle is then filled with water,[3] permitting the stream to stir up the contents, and allowed to stand for 10 minutes, when by means of a siphon extending to within 2.5 centimeters (approximately 1 inch) of the bottom of the receptacle, the water is siphoned off. More water is added, filling the receptacle, and at the end of 10 minutes siphoned off. Water is added again, and at the end of 5 minutes siphoned off. The process of 5 minutes standing and siphoning is repeated until the water remains clear at the end of the 5-minute period. By this means the clay substance is separated from the grain, and may be collected in suitable containers and recovered by the addition of acid to neutralize the sodium hydroxide.

The grain remaining in the bottle or jar is washed onto a filter-paper, in a 9-centi-

[1]Op. cit.
[2]The bottles used were quart milk bottles, which gave a settling column 8½ inches in height.
[3]As tap water caused the clay to flocculate and settle before the latter could be siphoned off, it was found necessary to use water free of positive electrolyte, such as distilled water or power-plant boiler water.

meter Buchner's funnel, is transferred, together with the filter-paper, to a large glass, and dried for ½ hour at a temperature which shall not be lower than 105 degrees Centigrade nor higher than 110 degrees Centigrade. The dried grain is weighed, and the difference between its weight and that of the original 50-gram sample is ascertained to determine the clay substance.

The grain is then placed on the first of a series of sieves, U. S. Bureau of Standards Nos. 6, 12, 20, 40, 70, 100, 140, 200 and 270. These sieves are placed in a Rotap testing-sieve shaker[1], or other machine the use of which may yield identical results. This machine is run for 15 minutes, and the amount remaining on each sieve is weighed, and expressed in percentage. The portion passing the No. 270 sieve is known as "No. 270 minus," or "—270 mesh."

TABLE 4.—*Series of sieves, United States Bureau of Standards*

| Sieve number | Sieve opening | | Wire diameter | | Tolerance | | |
|---|---|---|---|---|---|---|---|
| | | | | | In average opening | In wire diameter | In maximum opening |
| | *Millimeters* | *Inches* | *Millimeters* | *Inches* | *Per cent* | *Per cent* | *Per cent* |
| 6 | 3.36 | .132 | 1.02 | .040 | 3 | −15 to +30 | 10 |
| 12 | 1.68 | .0661 | .69 | .0272 | 3 | −15 to +30 | 10 |
| 20 | .84 | .0331 | .42 | .0165 | 5 | −15 to +30 | 25 |
| 40 | .42 | .0165 | .25 | .0098 | 5 | −15 to +30 | 25 |
| 70 | .210 | .0083 | .140 | .0055 | 6 | −15 to +35 | 40 |
| 100 | .149 | .0059 | .102 | .0040 | 6 | −15 to +35 | 40 |
| 140 | .105 | .0041 | .074 | .0029 | 8 | −15 to +35 | 60 |
| 200 | .074 | .0029 | .053 | .0021 | 8 | −15 to +35 | 60 |
| 270 | .053 | .0021 | .041 | .0016 | 8 | −15 to +35 | 90 |

### GRAPHICAL REPRESENTATION OF FINENESS DATA

It is well to file all fineness data obtained. Printed blanks which have appropriate spaces for sample data, size grade percentages, etc., may be used. Some sort of graphic record is also very effective, as the relation of the various size-grade percentages are evident at a glance; figures 28, 31, and 34 show fineness pyramids which are simply made, easily read, and self explanatory.

### RELATION OF FINENESS TO OTHER PHYSICAL PROPERTIES

The relation of fineness to other physical properties of molding sand will be considered later in the chapter, following the description and definition of the other physical properties.

## BOND STRENGTH

### FUNCTION

A natural-bonded molding sand must possess sufficient bond strength so that, when moist, the sand will retain the shape of a pattern, and keep that shape against the washing effect of the molten metal.

[1]Manufacturers of equipment used in making Standard Tests are listed in the American Foundrymen's Association bulletin, op. cit.

Coarse sands must have a higher degree of bond strength than fine sands because larger molds are made of them, and because the washing effect of the molten metal is greater. Sands used for light castings do not require as high bond strength but the molding of intricate patterns calls for a wide moisture range, through which the bond must remain as nearly constant as possible.

### CONTRIBUTING FACTORS

Of the many factors which affect bond strength, some are inherent in the sand and others concern foundry practice. The initial bond strength is due to several factors inherent in the sand, which are as follows:

#### CLAY

1. Clay, when moist, adheres to sand grains, the strength of the adhesion depending upon the plasticity of the clay, the area of the surface covered, and the roughness of that surface. The plasticity of the clay at any one moisture content probably depends primarily upon the amount and degree of flocculation of the ultraclay present, but in any one molding sand this factor is very nearly constant. The relation of plasticity to moisture content is a factor which, within limits, can be controlled.

The ratios between varying amounts of clay and a constant grain surface of the sand are of importance during the use of a sand. Because the total grain surface varies with the size grade distribution of the sand grains, molding sand produced from a deposit of variable fineness does not have a constant grain surface but this factor is of less importance than the variations in the amount of clay present.

#### GRAIN SURFACE

2. The kind of grain surface is very important. Clay does not adhere to the smooth surfaces of chert or quartz grains. The surfaces of clean quartz grains may be exposed by breaking a damp lump of clay and quartz sand; but if the quartz grains are coated with a film of limonite, a break in a damp lump will not reveal the presence of the grains, as each grain has a coating of clay which adheres more tightly to its surface than to the body of the clay. The increase in bond strength which is effected by this grain coating is large—so large, in fact, that the successful synthetic manufacture of molding sand of low refractoriness from clean sand and clay is commercially impracticable.

#### SURFACE TENSION OF WATER FILM ON CRYSTALLINE GRAINS

3. A handful of moist sand will tend to adhere together, the adhesion being stronger, the finer the sand. The force of adhesion is known to be due to the surface tension of the water films surrounding the grains because an increase of moisture sufficient to saturate the sand destroys the adherence. The "packing" or interlocking of angular grains is commonly considered to be a factor in the bond strength of fine sands; but such interlocking, when tested with an absolutely dry, clean-surfaced, clay-free sand, does not develop measurable bond strength and is therefore known to have little or no importance in itself.

Some of the bond strength of any molding sand is contributed by the water film between silt grains, the higher the ratio between the amount of fine crystalline grains and the amount of clay, the greater its part of the total bond strength. In general, molding sands largely composed of fine crystalline grains will maintain a nearly constant bond strength throughout a narrow moisture range. The addition of some clay increases the moisture range of constant bond strength rather than the maximum bond strength.

## NEED FOR STUDY OF DETERMINING FACTORS

When the nature and number of the known factors involved in bond strength are considered, it is obvious that the determination of bond strength of a given sand must be done directly for it can not be derived from an analysis of the factors. However, better knowledge of the relative importance of each factor will further conservation and facilitate foundry control of molding sands.

## STANDARD BOND-STRENGTH TEST

The bond strength of the samples listed in this report (Tables 30 and 31) was obtained by the Standard Bonding or Cohesiveness Test recommended by the Joint Committee on Molding Sand Research,[1] which is as follows:

### *Tempering of Sand*

1. The sample to be tested should be an average one, representative of the heap, floor, car, bank, or other source from which it is taken.

2. In testing sand for cohesiveness it is absolutely necessary that the sand be properly sampled and uniformly tempered. For plant check or control tests upon facing or heap sands in daily use, one may test the sand as tempered for molding.

3. Since it is the object to determine the maximum cohesiveness under suitable foundry working conditions, in the examination of new sands experiment should invariably be made with several water contents in order to ascertain that amount (optimum water content) which develops the maximum degree of cohesiveness. It is advisable in most cases to try percentages of water beginning with 4 per cent and increasing by stages of 2 per cent, up to and including at least 8 per cent. Sometimes it will be found difficult to make a test with a water content of an exact predetermined percentage. The permissible extent of deviation from the predetermined amount should in no case be more than one-half per cent, and can be determined intelligently by the careful experimenter who observes critically the tendency of a sand to show widely differing cohesiveness values as the water content is appreciably changed. A deviation not exceeding .2 per cent (5.8 per cent or 6.2 per cent in the case of an attempt to get 6 per cent) can be considered as entirely satisfactory for the determination of the cohesiveness at the nearest fixed percentage. The exact percentage of moisture, even if within .2 per cent, should be reported. Supplementary tests with lower percentages of water than 4 per cent and higher percentages than 8 per cent should be made if and when the facts ascertained justify such tests. For example, when a permeability value considered proper to report is obtained on a sand with a moisture content below 4 per cent or above 8 per cent and a cohesiveness value on the sand is desired, the test for cohesiveness should be conducted with the sand tempered with the same amount of water as in the case of the permeability test. In such cases, a sufficiently large sample of sand should be tempered, to permit making both of these tests.

[1]American Foundrymen's Association bulletin, June 1, 1924 (Edition corrected August 1, 1924).

4. In the examination of new sands, proceed as follows: Dry 1000 grams of sand, selected according to the directions for sampling molding sand, for one hour at a temperature not below 105 degrees Centigrade, nor above 110 degrees Centigrade. Care should be exercised to spread the sand over a large area in a thin layer in order to expel all the moisture in a given time. This will make it possible to add the proper amount of water and give the sand the desired moisture content.

5. After the sand has cooled, measure out the desired quantity of water, adding sufficient extra water (usually from one-fourth to one per cent) to allow for evaporation during mixing. Thus if it is desired to add 4 per cent water and one-half per cent extra

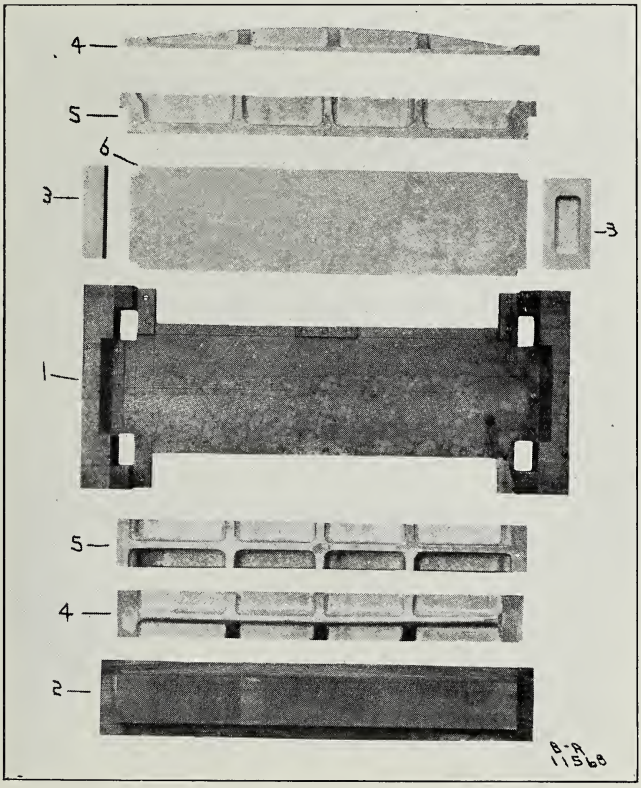



FIG. 1.—Mold box parts for bond test

water is needed, one would add 47 cubic centimeters (since one cubic centimeter of water weighs 1 gram) to 1000 grams, and secure a total weight of 1047 grams.[1]

6. For the tempering operation, spread the sand on a smooth flat dry surface in a layer about 1 inch thick, sprinkle a small quantity of the required water evenly over the sand, and work the latter gradually into a heap by rubbing it vigorously through the hands. Again spread it into a thin layer and repeat the above operations, adding more water. Continue to do this until all of the water has been thoroughly distributed through the sand. There should be no dry lumps or other evidence of uneven tempering.

[1]Moisture content for all molding sand determinations and tests is to be expressed as the percentage of moisture in the *damp* sample of sand. It is not proper to calculate the amount of moisture, proportionate to the weight only of the dry sand.

7. The sand should now be allowed to stand in order that the maximum temper may be developed. To secure this temper, place the sand in a humidor or air-tight receptacle and allow it to stand for 24 hours. After this, the sample is ready to be tested, as below.

8. Take the entire sample of sand from the humidor. Pass this entire sample twice through a coarse riddle and return the sand as quickly as possible to the humidor or receptacle. From this take sample to be tested for cohesiveness; also sample to be tested for moisture content, and for permeability if desired.

*Ascertaining Moisture Content*

9. The moisture content is to be determined as follows: Dry 100 grams of tempered sand for one hour between 105 degrees and 110 degrees Centigrade. When dry re-weigh. The loss of weight in grams is the moisture content expressed as percentage.

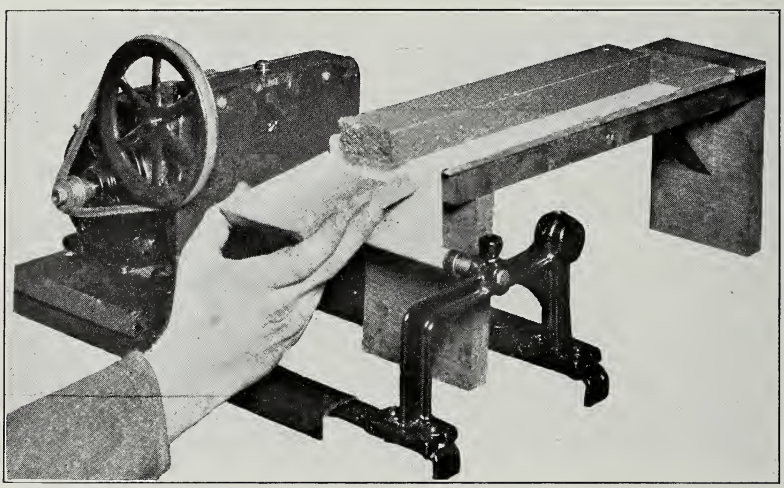


FIG. 2—Constant-speed motor pulling device for breaking bond test bars

*Method of Procedure in Testing for Cohesiveness*

10. While the sand is drying remove all loose pieces from the box as shown in figure 1. Replace metal plate (No. 6, fig. 1) in frame (No. 1, fig. 1), locating the plate between the small projections on the bottom of the frame; and upon this plate[1] place a piece of thin waxed or oiled paper which is of the same width as the end of the plate, but long enough to be inserted in the slotted shaft of the motor-pulling device (fig. 2). One end of the strip of paper should be even with one end of the plate, and the other should project and be turned around the other end of the plate, so as to lie smoothly against its under side. Replace sections 5 (fig. 1), moving them as far toward the outer edge of the frame as is possible. Then replace sections 3 (fig. 1). Place the open box directly beneath the riddle which is shown together with the box and strikes in figure 3.

11. Take a sufficient quantity (approximately 1000 grams) of tempered sand to make a bar one inch thick, with a tolerance of not more than three per cent. Place the weighed sand and some tumbling stars in the riddle, and shake until the sand has passed through it.[1] Remove the box from beneath the riddle, and brush all particles on top of sides of box, into same.

[1]The metal plate can be made of aluminum, brass, or of some other non-corrosive metal. The light weight of aluminum makes it preferable for handling.

12. Level off the sand in the box by using the strikes shown in figure 4. In striking off, it is important to start with that strike which grazes the highest level of the sand, working from the center alternately toward the ends of the box, and swinging the strikes around as the ends are approached, so that no sand will be packed between the strike and the end of the box. Continue the use of strikes consecutively deeper by 1/16 inch until a uniform level of sand is obtained throughout the box.

13. Starting with section 5 on one side of the box, push it toward the center as far as possible, and hold in position by inserting section 4 (fig. 5). Repeat this operation on opposite side.

14. Place the trussed rammer (fig. 6) in a level position on the sand in the box. Place the box with the trussed rammer in an impact machine similar to that shown in

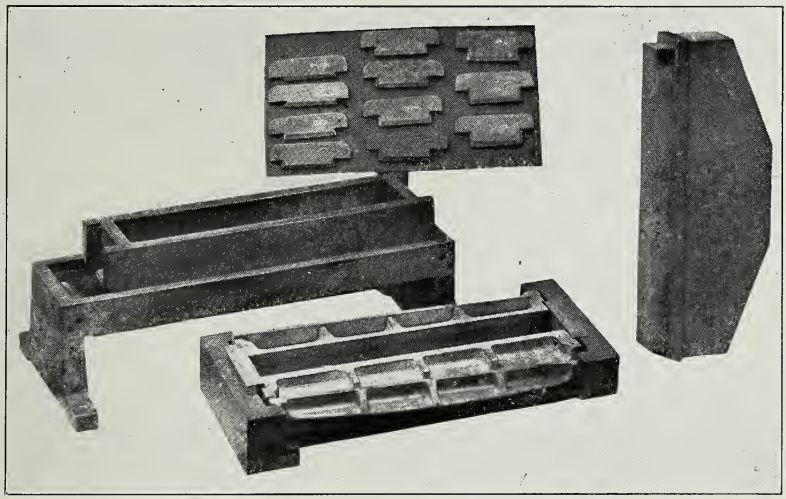


FIG. 3.—Assembled mold box, screen, and rammer block for bond test

fig. 7, so that the weight will fall on the center of the truss. Drop a twenty-pound weight three times from a height of sixteen inches.

15. Remove box with trussed rammer from impact machine. Then remove trussed rammer and sections 4, 5 and 3 in the order named. In removing section 3 be especially careful to push it away from the bar as it is being lifted.

16. Remove metal plate supporting the bar lying on the paper. With a scale divided into hundredths of an inch, measure both sides of the bar at three points to determine the average thickness, considering the inch to be the unit of thickness. The thickness should be uniform, but experiments have shown that variations in thickness do not appreciably affect the results when the deviations in the thickness of the bar do not vary from the prescribed one inch dimension, over or under, at any point, by more than .02 inch. Set the plate carrying bar and paper on the table of breaking apparatus (fig. 2), with one end of the plate projecting about one-half inch beyond the end of table. The free end of the paper should extend from the projecting end of the plate, and should pass through the slot in the shaft of the motor-pulling device (fig. 2).

[1]In the case of some coarse sands like Millville gravel there is a tendency for the finer particles to go through the screen of the riddle first, the coarser particles and pebbles passing through later. This tends to give a layered structure to the bar, which is undesirable. Where the sand shows such a tendency the use of a coarser screen in the riddle for feeding the material into the box is permissible.

17. Start the motor-pulling device,[1] which draws the bar forward at the rate of six inches per minute. When the weight of the overhanging section causes a portion of the bar to break off, stop the motor. Catch the portion breaking off in some convenient

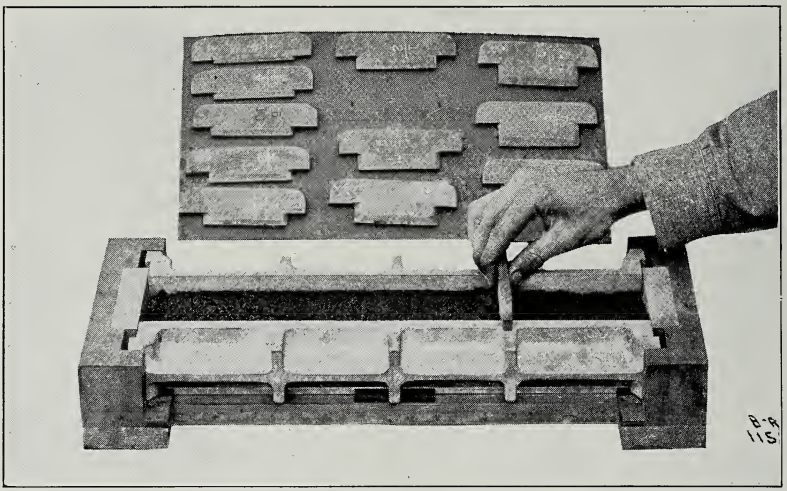


FIG. 4.—Showing method of leveling sand in mold box using graduated strikes of graduated depth

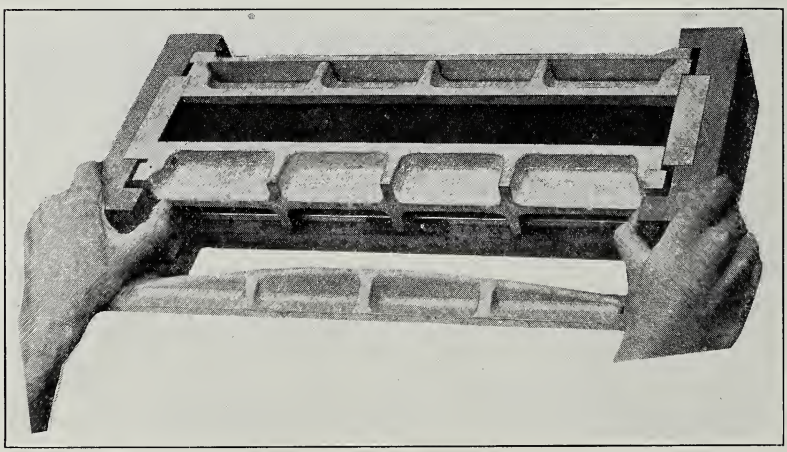


FIG. 5.—Showing method of assembling mold box after sand has been riddled in box.

receptacle (as illustrated in fig. 2) which has been previously weighed. This receptacle may be a piece of thin metal which has been bent into a shape similar to a bowl or scoop

[1]Instead of the motor-pulling device illustrated, any suitable form of apparatus may be used, which employs power geared to a shaft in such ratio that the said shaft to which the paper is attached will be revolved at a constant speed to draw the bar at six inches per minute. A steady forward movement of the bar for each break is imperative. For intelligent comparison of results a uniform pulling speed, to be employed by all operators, is necessary. A speed of six inches is adopted because it has been found satisfactory with weak and strong sands.

so as to safeguard the catching of every particle of sand as it falls. Weigh the receptacle and every particle of the broken portion of the bar together, and deduct the weight of

FIG. 6.—Rammer block for bond test

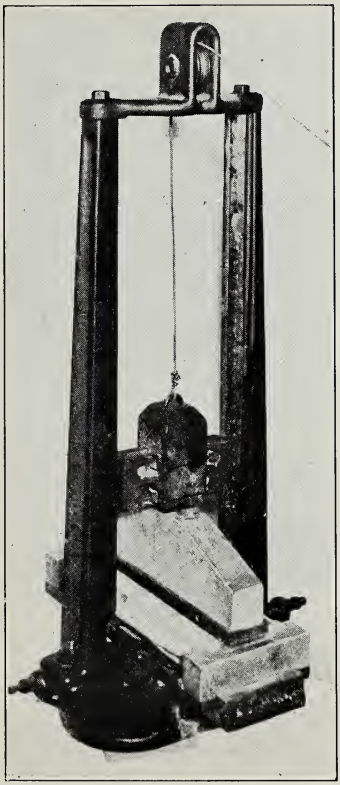


FIG. 7.—Ramming apparatus for compressing sand in mold box for bond test

the receptacle. Repeat the operation until as many breaks are obtained as the bar will yield. To prevent the last part of the bar from tilting a broad flat weight of proper size may be placed on the end of the bar to hold it down.

*Disposition of Results from Tests*

18. If the bar breaks into portions of fairly uniform weights, all breaks may be retained. If the first break differs by more than 10 per cent from the average weight of the others, discard it. Appreciable variations between the weight of the first break and those of the other breaks may be due to the influence on certain sands of close contact with the end piece of the box (No. 3, fig. 1). Should the weight of any break other than the first differ from the average weight of the others by more than 10 per cent, discard the entire bar. This difference is usually traceable to improper mixing of the sand or careless use of strikes.

19. Add the weights of all broken sections (except any which may have been discarded) and divide by the number of these. This gives the average breaking weight for a bar of the thickness used. Repeat this operation, until at least six breaks have been obtained from not less than two bars, and average the results of the average breaks from each bar. If properly carried out, the test of the number of bars as specified should yield an average from which no individual bar should vary more than 5 per cent. Failure to meet this requirement indicates faulty manipulation.

20. The bonding strength is to be expressed in terms of the actual weight in grams of the average breaking strength of the bar, including moisture.

*Example A*

*Bonding Strength* = $213.6 \times 100 \div 500 = 213.6 \div 5 = 42.7$ *per cent.*

*Example B*

*Bonding Strength* = $252.9 \times 100 \div 500 = 252.9 \div 5 = 50.6$ *per cent.*

21. From the above examples it is seen that the average weight of the breaks, divided by 5, gives the bonding strength or cohesiveness expressed in percentage.

22. Having completed the test on samples with varying moisture contents, report the bonding strength or cohesiveness of each, with its corresponding moisture content.

## RELATION OF CLAY AND SILT TO BOND STRENGTH

The interrelation of the two factors, amorphous clay and crystalline silt, in determining the degree of bond strength is shown in Table 5. As it is impossible to eliminate or keep constant the amount of grain coating, the size-grade distribution of the sand grains, and the plasticity of the clay, the possibility should be recognized that the tendencies shown may be due in part, or wholly, to other factors.

All the samples tested are represented in this table, the bond strengths given being averages of the bond strengths of the samples which fell in each group. Several of the silt-clay percentage combinations include only one sand, so that some of the figures are representative of single samples.

Two tendencies are noticeable:

1. The silt content being constant, the bond strength tends to increase with increase in clay content.

2. The clay content being constant, the difference between the maximum and minimum bond strength values in the 4 per cent to 8 per cent moisture-content range tends to decrease with increase in silt content.

TABLE 5.—*Relation of average clay and silt percentages to bond strength.**

| Silt (−270 mesh) | Clay | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 to 10 per cent | | | 10 to 15 per cent | | | 15 to 20 per cent | | | 20 to 25 per cent | | | 25 to 30 per cent | | |
| | Percentage of moisture | | | | | | | | | | | | | | |
| | 4 | 6 | 8 | 4 | 6 | 8 | 4 | 6 | 8 | 4 | 6 | 8 | 4 | 6 | 8 |
| Per cent | Average bond strength | | | | | | | | | | | | | | |
| 0— 5 | **220.4** | 152.4 | 130.7 | **263.1** | 234.9 | 182.2 | **311.7** | 305.7 | 273.1 | **307.9** | 300.8 | 276.4 | ..... | **305.8** | 202.0 |
| 5—10 | ..... | **150.4** | 110.5 | **238.9** | 202.7 | 172.1 | 276.6 | **290.4** | 269.0 | **309.4** | 297.3 | 287.8 | ..... | ..... | ..... |
| 10—15 | **186.1** | 161.7 | 132.9 | **238.9** | 221.2 | 183.0 | 241.7 | **248.4** | 216.9 | 262.1 | **293.5** | 293.2 | 308.8 | 309.4 | **323.8** |
| 15—20 | **188.4** | 149.8 | 133.9 | **192.7** | 188.9 | 182.5 | 198.8 | **252.4** | 239.6 | 294.2 | **299.8** | 292.8 | 270.6 | 270.7 | 279.3 |
| 20—25 | ..... | ..... | ..... | **241.8** | 210.7 | 201.4 | 193.3 | **224.1** | 199.9 | 228.5 | 263.0 | **290.6** | ..... | ..... | ..... |
| 25—30 | **163.8** | 160.7 | 151.1 | **235.0** | 234.9 | 217.1 | **237.1** | 225.8 | 210.2 | **278.8** | 242.0 | 240.1 | 310.3 | **362.0** | 337.2 |
| 30—35 | 191.3 | **194.2** | 182.8 | ..... | ..... | ..... | 225.7 | **248.9** | 221.9 | ..... | ..... | ..... | 264.9 | 270.9 | **303.7** |
| 35—40 | **175.6** | 157.0 | 144.0 | **216.0** | 190.3 | 172.9 | 145.4 | 166.7 | **202.1** | 261.5 | 271.5 | **289.4** | 285.0 | 290.6 | **297.6** |
| 40—45 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 220.3 | **250.5** | 236.6 | ..... | 199.1 | **241.4** |
| 45—50 | ..... | ..... | ..... | **267.2** | 254.5 | 231.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 50—55 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 245.0 | **282.1** | 263.4 |
| 55—60 | 151.9 | 156.3 | **160.7** | ..... | 168.5 | **177.2** | ..... | ..... | ..... | 188.4 | 248.3 | **262.4** | ..... | ..... | ..... |
| 60—65 | ..... | ..... | ..... | ..... | **254.2** | 228.1 | 255.0 | **286.5** | 257.0 | ..... | ..... | ..... | ..... | ..... | ..... |
| 65—70 | ..... | ..... | ..... | **258.0** | 243.3 | 231.9 | 219.2 | **256.6** | 227.7 | ..... | ..... | ..... | ..... | ..... | ..... |
| 70—75 | ..... | ..... | ..... | ..... | ..... | ..... | 165.3 | 202.2 | **207.6** | ..... | ..... | ..... | ..... | ..... | ..... |
| 75—80 | 164.1 | **183.6** | 173.3 | 231.6 | 238.3 | **254.9** | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 80—85 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 85—90 | 145.0 | **186.0** | 172.6 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

*Bold-face figures indicate the maximum average bond strength within the indicated moisture-content range for each clay-silt combination.

### RELATION OF CLAY AND SILT CONTENT TO OPTIMUM WATER CONTENT FOR BOND STRENGTH

Table 6 shows the average silt and clay content of groups of samples which attain maximum bond strength at 4 per cent, 6 per cent, and 8 per cent water, respectively. The group which has maximum bond strength at 4 per cent averages low in both silt and clay content, and has very nearly equal amounts of silt and clay. At 6 per cent and 8 per cent the silt and clay contents average higher, and the average silt percentage is greater than that of the clay, though the clay-silt ratio is practically the same.

It is clear that the higher the percentages of silt and clay in molding sand the higher will be the water per cent at which maximum bond strength will be developed.

TABLE 6.—*Relation of optimum water content for bond strength to silt and clay content*

| Moisture content at maximum bond strength | Number of samples | Average silt content (−270 mesh) | Average clay content |
|---|---|---|---|
| *Per cent* | | *Per cent* | *Per cent* |
| 4 | 57 | 15.3 | 13.2 |
| 6 | 45 | 26.6 | 17.1 |
| 8 | 32 | 32.8 | 21.6 |

## DURABILITY

### VALUE OF TESTING

A need for a test of the durability of molding sand has been evident, as a sand which has a low degree of durability may not be profitably used even though the fineness, permeability and cohesiveness tests indicate its suitability. The problem of durability, or life of a sand, is distinct from the problem of refractoriness or resistance to fluxing, as it is conceivable that a very refractory sand might be short-lived. The general procedure of durability tests developed and used in plant control work by H. W. Dietert was adopted after some experimentation with temperatures at 500 degrees, 600 degrees, 1000 degrees to 1250 degrees, and 1800 degrees Fahr. A temperature of 600 degrees Fahr., which is that used by Mr. Dietert, was found to be best suited for obtaining results apparently indicative of durability. Lower temperatures gave little differentiation between sands, and temperatures above 1000 degrees appeared to dehydrate so much of the clay substance that the bond strength was due largely to adhesion between grains which had burnt-on coats of "dead" clay. At 1800 degrees the bond strength was entirely lost in the few samples tested at that temperature.

The foundry problem of durability relates to the partially burnt sand which goes back into the heap and not to the sand which is entirely burnt

out and discarded. Hence it is desirable to know the loss of bond strength at low temperatures. Such a test is largely an aid in gaging the durability of new sand.

### STANDARD DURABILITY TEST

Three pounds of untested, air-dried sand broken up to pass a No. 6 riddle, is put into a sheet-iron or aluminum pan of such size that the sample may be spread evenly in a layer about one-fourth of an inch thick. The sand is placed in a gas core oven which is heated until the shelf on which it rests reaches 600 degrees Fahr., when a thermo couple is laid on top of the sand. Uniform temperature is maintained for two hours, a tolerance of 15 degrees Fahr. being allowed after the sand reaches 600 degrees Fahr. After being removed from the oven, the sand is spread in a thin layer on an iron core bench and allowed to cool for two hours. It is then tempered to the optimum water content for bond strength and allowed to temper for twenty-four hours. The test for bond strength is made in accordance with the procedure of the Standard Cohesiveness Test. The difference between the bond strength of the heated sample and the bond strength at optimum water content of the usual sample is the loss which is best stated as percentage of the maximum bond strength of the sample.

The durability bond test data given in Tables 30 and 31 were obtained at the optimum water content determined by the usual test. Quite probably the optimum water content changes somewhat on heating and although no specific data can be advanced in support, it seems probable that excessively high or excessively low bond-strength losses may be due in part to migration of the optimum water content. The importance of this factor must be established or disproved before sands testing low in durability be condemned or those showing a high durability or a slight gain be accepted with full confidence.

### RESULTS

Not enough data are available to allow conclusions on durability. Theoretically, it would seem that sands having a high clay content would lose a higher percentage of bond strength than sands of less clay content bonded by the surface tension of the water film surrounding minute crystalline grains. Table 7 gives data which, in general, support this idea. The samples which lost less bond strength had a higher average silt content than those which lost a high percentage of bond strength. The clay-content data show no definite trend. It seems probable that the plasticity of the clay and the grain coating of limonite are so important that each sand is highly individual in its behavior.

While the relation of iron oxide bond to durability was not studied in any detail, it is interesting to note that Sample No. 183 (Table 30), which contained only iron-oxide bond lost 21.5 per cent of its bond strength.

### NEED FOR FURTHER STUDY

It is hoped that the physical property of durability will receive the attention it deserves. Foundry practice is the final judge in weighing the

value of any test and a check by plant-control men on the life of the sands in present use would be of considerable advantage.

TABLE 7.—*Relation of silt and clay content to durability*

| Bond strength | Number of samples | Silt (−270 mesh) Average per cent | Clay Average per cent |
|---|---|---|---|
| *Per Cent* | | | |
| Gain 0— 5 | 4 | 36.4 | 11.6 |
| Loss 0— 4.9 | 4 | 30.4 | 26.3 |
| Loss 5— 9.9 | 11 | 34.6 | 16.3 |
| Loss 10—14.9 | 8 | 22.4 | 13.9 |
| Loss 15—19.9 | 7 | 17.5 | 14.4 |
| Loss 20—24.9 | 4 | 13.4 | 15.9 |
| Loss 25—29.9 | 4 | 11.0 | 16.8 |
| Loss 30—34.9 | 3 | 18.1 | 11.1 |
| Loss 35—39.9 | 2 | 9.4 | 22.7 |

## PERMEABILITY

### FUNCTION

Permeability is the property which allows the passage of gas through molding sand, or, in other words, it is continuous porosity. It is a requisite property of molding sand for the reason that gases from the molten metal and the steam developed when the hot metal comes in contact with the damp sand of the mold, must have free vent. The data on natural permeability given in this report were obtained by the Standard Permeability Test recommended by the Joint Committee on Molding Sand Research,[1] which is as follows:

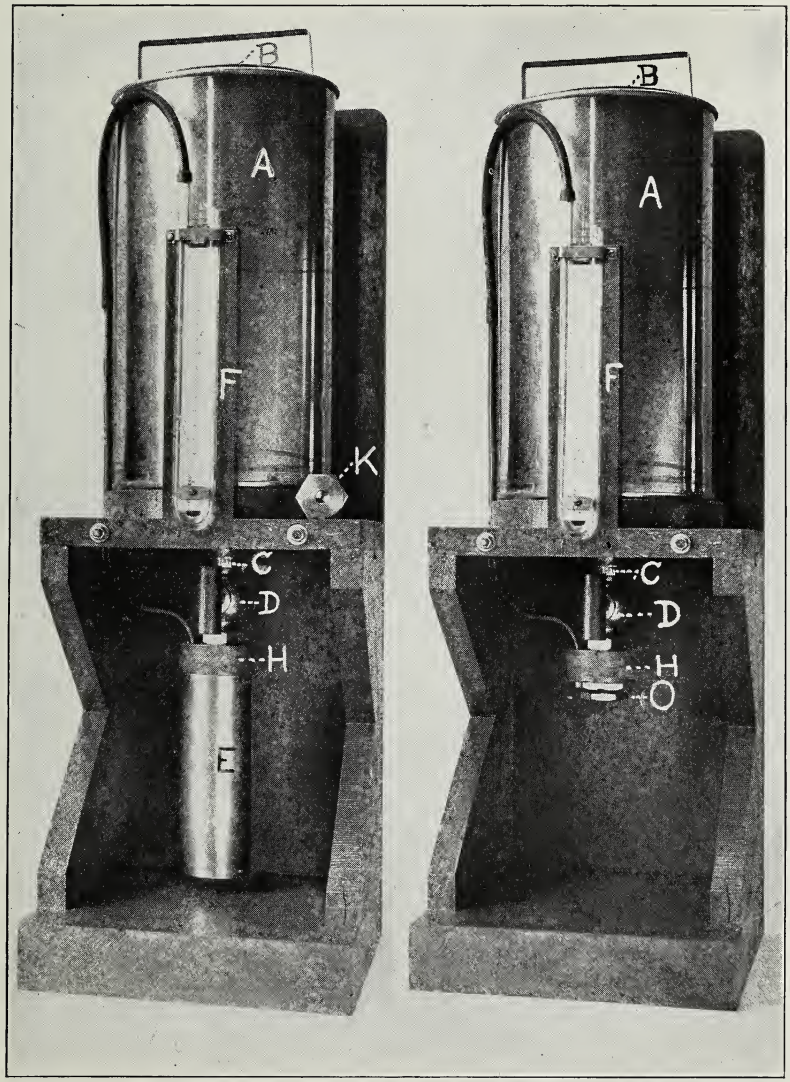
### STANDARD PERMEABILITY TEST

*Permeability Apparatus*

The parts[2] of the permeability apparatus are as follows: Tank A (figs. 8 and 9) is made of copper, tin lined, and is provided with a vertical air outlet tube coming up through the bottom of the same. When in use this tank is partly filled with water, as described in paragraph 21. A stop-cock is provided on the side of tank A at the bottom, to drain off the water when the apparatus is not in use, or when adjusting the water-level. Bell B has a vertical tube (C-1, fig. 9) which slides inside the air outlet tube (C-2, fig. 9) in tank A. Near the top of this tube are several vents to permit the air to be forced out of bell B. A three-way valve D (shown assembled in fig. 8) is attached to the lower end of the outlet tube from tank A. The opening in the valve should not be too small, preferably not less than .12 square inches (3 square millimeters), so as to permit the air to pass through freely. The parts of this valve are shown as D1 to D4, inclusive (fig. 9). A valve-indicator, D3, is provided, marked "On," "Off," and "Vent," to show when the valve is in position to let air from bell B through sand in sand container E; to shut off flow of air from bell; or to permit air to enter by-pass while raising the bell. A

[1]Op. cit.
[2]Dimensions of the different parts are given on the parallel perspective drawing (fig. 9).

nipple G, over which fits a rubber stopper H, which is held in place by two locknuts I and J, is attached to the lower side of the valve. An orifice-plate K for use in rapid work, is screwed into the lower end of the nipple G. One of the orifice-plates can be seen on the




A B

FIG. 8.—Permeability testing apparatus. The apparatus on the left has a sand container (E) in place ready for testing.

shelf at base of tank (fig. 8A). The rubber stopper H fits into a sand container E. In front of the tank A, there is a manometer F, having a scale divided into centimeters and millimeters. This connects with a brass tube that passes down through the rubber stopper

H. All parts are of brass, except those described as being made of other materials, and except the stand or base.

As the bell B sinks into the water in tank A, it forces air into the outlet pipe C-1 (fig. 8) through the valve D (fig. 8), and through the sample of sand packed in the

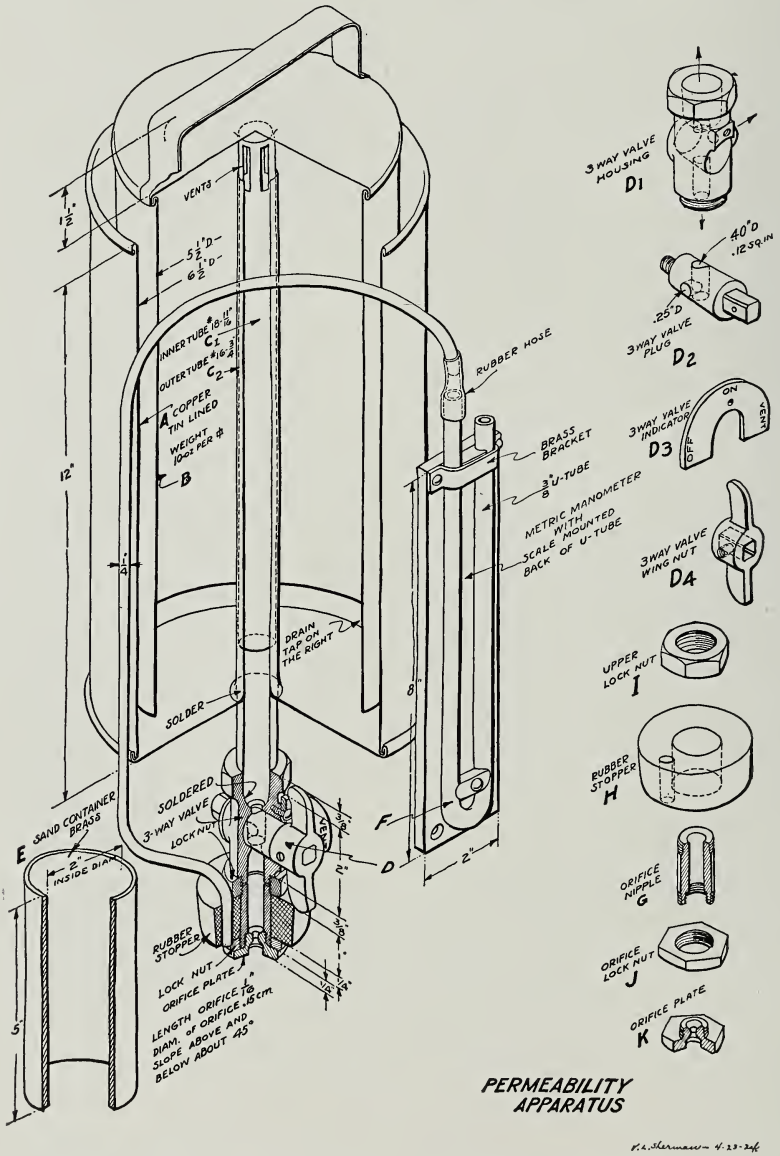



FIG. 9.—Parallel perspective drawing of permeability testing apparatus.

container E (fig. 8A). The pressure of this air is read on the manometer F. Since the pressure recorded on the manometer depends on the weight of the bell B, and on its cross-sectional area, the weight should be made such as to give a pressure of about, but not

less than 1.1 ounce per square inch (5 grams per square centimeter).[1] There should also be a weight provided, which can be placed on top of bell B, sufficient to increase the manometer pressure reading to 10 centimeters. This latter pressure is more convenient for testing very fine sands and for rapid work. An easily graduated weight is a bag of shot.

The bell B has several lines marked on it, the lowest being "X," the second "O," the next "1000" and the fourth "2000." These indicate that the capacity of the bell between the "O" and "1000" marks is 1000 cubic centimeters (61 cu. in.), and between "O" and "2000" it is 2000 cubic centimeters (122 cu. in.).

The object of having the mark "X," which is about ¾ inch (19 millimeters) below the zero mark, is to insure raising the bell to the proper height, so that when it is

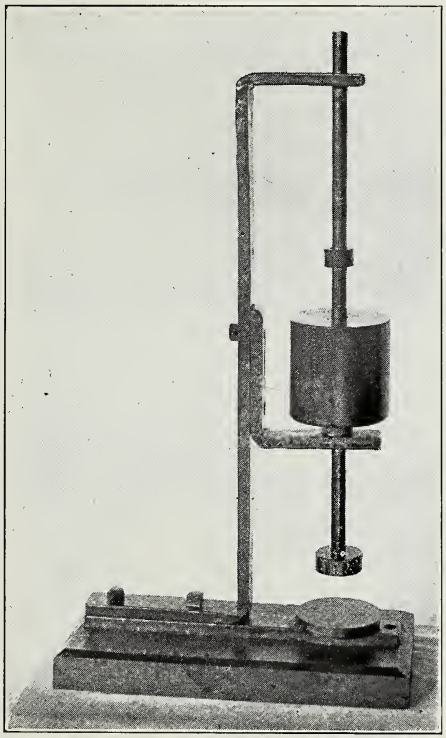


FIG. 10.—Ramming device for permeability test

necessary in a standard test to read the time required for the bell to sink from zero to 1000 or 2000, the zero mark will be clearly visible.

To raise the bell, turn the indicator on valve plug to "Vent" (fig. 9). This allows air to enter through the by-pass instead of having to be drawn through the sand. Then turn indicator to "Off," and the bell will remain in its raised position. When ready to start the test, turn indicator to "On," and the bell will sink as air is forced through the valve.

The sand container E (fig. 8A) is a brass cylinder 5 inches (12.70 centimeters) high and 2 inches (5.08 centimeters) inside diameter.

[1]If less than 5 centimeters pressure is recorded the bell sinks too slowly when a very fine sand is being tested. The amount of pressure can be determined by attaching the empty sand container to the apparatus, plugging its lower end with a cork, and opening the valve.

The sand rammer is shown in figure 10, with detailed drawings in figure 11. It consists of a steel rod, supported by two guides. A steel disc is attached to the lower end of the rod, and has a sliding fit in the sand container E (fig. 8A). A cast iron rammer head, weighing 14 pounds (6350.36 grams), slides on the rod, its movement being regulated by two stops. The distance between these stops is sufficient to permit a 2 inch

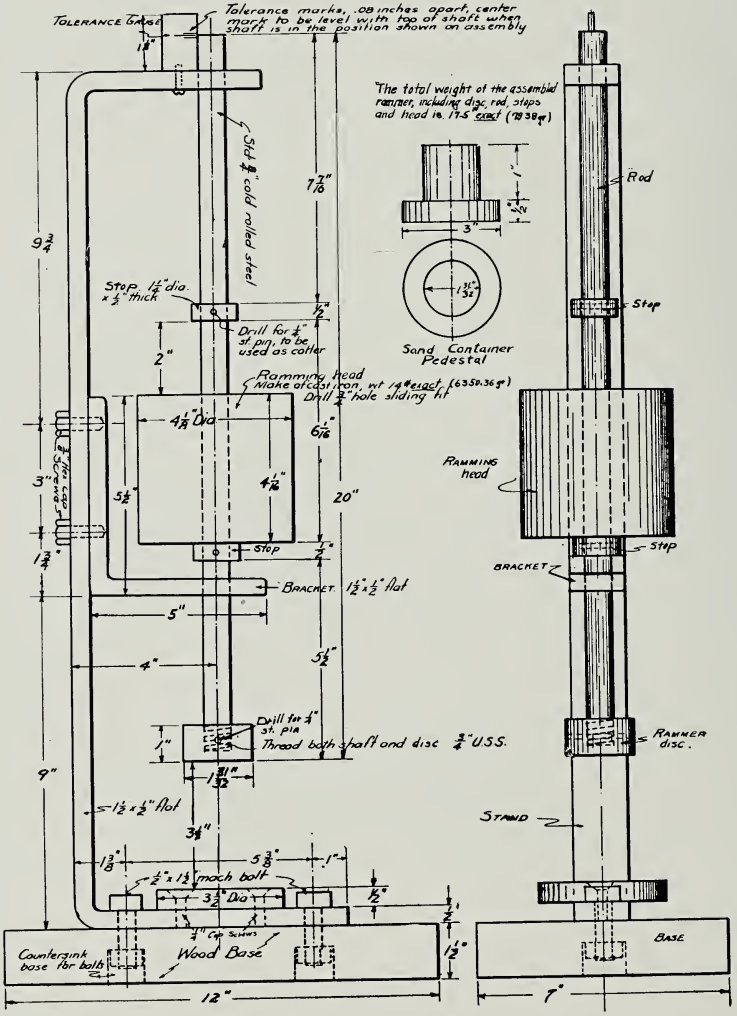

Tolerance marks, .08 inches apart, center mark to be level with top of shaft when shaft is in the position shown on assembly
Tolerance Gage
"The total weight of the assembled rammer, including disc, rod, stops and head is 17.5 exact (7938 gr)
Rod
Stop
Sand Container Pedestal
Stop, 1¼" dia. x ¼" thick
Drill for ¼" st. pin, to be used as collar
Ramming Head Make of cast iron, wt 14# exact (6350.36 gr) Drill ¾" hole sliding fit
Ramming head
Bracket
Bracket 1½" x ½" flat
Drill for ¼" st. pin
Thread both shaft and disc ¾" U.S.S.
Rammer disc.
Stand
1½" x ½" flat
¼" x 1½" mach bolt
¾" Dia
¼" Cap Screws
Countersink base for bolts
Wood Base
Base
12"
7"

Fig. 11.—Drawing of ramming device for permeability test

(5.08 centimeters) movement of the rammer-head. A pedestal is provided on which the sand container E rests while sand is being placed in it; and while the ramming operation is being performed. This pedestal is shown in fig. 11.

On top of the upper steel guide is attached a scale with 3 lines marked on it. If the upper end of the rammer rod is between the upper and lower of these lines after the third ram, it indicates that the sand sample is within the allowable limits of thickness.

If dry sand is to be tested, a special cap having a 20-mesh brass screen bottom should be used, to slip over the end of the sand container. For ramming dry sand the pedestal can be placed upside down under the container. This supports the screen during ramming, and keeps the sand sample at proper height to use the tolerance marks as a guide.

*Preparation of Sample*

The sample to be tested should be an average one, representative of the heap, floor, car, bank or other source from which it is taken.

*Tempering of Sand*

In testing sand for permeability it is absolutely necessary that the sand be properly sampled and uniformly tempered. For plant check or control tests upon facing or heap sands in daily use, one may test the sand as tempered for molding.

Since it is the object to determine the maximum permeability under suitable foundry working conditions, in the examination of new sands experiments should invariably be made with several water contents in order to ascertain that amount (optimum water content) which develops the maximum degree of permeability. It is advisable in most cases to try percentages of water beginning with 4 per cent and increasing by stages of 2 per cent, up to and including at least 8 per cent. Sometimes it will be found difficult to make a test with a water content of an exact predetermined percentage. The permissible extent of deviation from the predetermined amount should in no case be more than one-half per cent, and can be intelligently determined by the careful experimenter who observes critically the tendency of a sand to show widely differing permeability values as the water content is appreciably changed. A deviation not exceeding .2 per cent (5.8 per cent or 6.2 per cent in the case of an attempt to get 6 per cent) can be considered as entirely satisfactory for the determination of the permeability at the nearest fixed percentage. The exact percentage of moisture, even if within .2 per cent, should be reported. Supplementary tests with lower percentages of water than 4 per cent and higher percentages than 8 per cent should be made if and when the facts ascertained justify such tests. For example, when a cohesiveness value considered proper to report is obtained on a sand with a moisture content below 4 per cent or above 8 per cent and a permeability value on the sand is desired, the test for permeability should be conducted with the sand tempered with the same amount of water as in the case of the cohesiveness test. In such cases, a sufficiently large sample of sand should be tempered, to permit making both of these tests.

In the examination of new sands, proceed as follows: Dry 1000 grams of sand, selected according to the directions for sampling molding sand, for one hour at a temperature not below 105 degrees Centigrade nor above 110 degrees Centigrade. Care should be exercised to spread the sand over a large area in a thin layer in order to expel all the moisture in a given time. This will make it possible to add the proper amount of water and give the sand the desired moisture content.

After the sand has cooled, measure out the desired quantity of water, adding sufficient extra water (usually from one-fourth to one per cent) to allow for evaporation during mixing. Thus if it is desired to add 4 per cent water and one-half per cent extra water is needed, one would add 47 cubic centimeters (since one cubic centimeter of water weighs 1 gram) to 1000 grams, and secure a total weight of 1047 grams.[1]

For the tempering operation, spread the sand on a smooth flat dry surface in a layer about 1 inch thick, sprinkle a small quantity of the required water evenly over the sand, and work the latter gradually. Again spread it into a thin layer and repeat the

[1]Moisture content for all molding sand determinations and tests is to be expressed as the percentage of moisture in the *damp* sample of sand. It is not proper to calculate the amount of moisture, proportionate to the weight only of the dry sand.

above operations, adding more water. Continue to do this until all of the water has been thoroughly distributed through the sand. There should be no dry lumps or other evidence of uneven tempering.

The sand should now be allowed to stand in order that the maximum temper may be developed. To secure this temper place the sand in a humidor or air tight receptacle, and allow it to stand for 24 hours. After this, the sample is ready to be tested, as below.

Take the entire sample of sand from the humidor. Pass this entire sample twice through a coarse riddle and return the sand as quickly as possible to the humidor or receptacle. From this take sample to be tested for permeability; also sample to be tested for moisture content, and for cohesiveness if desired.

*Ascertaining Moisture Content*

The moisture content is to be determined as follows: Dry 100 grams of tempered sand for one hour between 105 degrees and 110 degrees Centigrade. When dry re-weigh. The loss of weight in grams is the moisture content expressed as percentage.

*Ramming of Specimen*

Take a sufficient quantity (from 150 to 200 grams) of tempered sand to make a column 2 inches (5.08 centimeters) high, with a tolerance of 4 per cent. The sand should be carefully placed in the container E, and gently leveled off. Place pedestal and container with sand in position beneath rammer. Gently lower rammer-rod with head into container until they are supported by the sand. Raise rammer-head to the upper stop, and let fall. Repeat twice, making a total of 3 rams. Note whether the upper end of the rod is within the tolerance marks. If not, discard the sample and put in another lot of tempered sand of sufficient quantity to yield a column of the required height. This is usually accomplished on the second trial. Lift rammer-rod until disc at lower end of rod is free from the sand container, and take container off pedestal.

*Measurement of Air Flow*

Fill tank A with water to within 4¾ inches (12.2 centimeters) of the top. Before attaching sand container with specimen, open valve D, and raise bell B until mark "X" appears. Then close valve D. Attach sand container to rubber stopper H, moistening sides of stopper before applying, to prevent air leakage. Open valve D. Note scale on side of bell B, and as cup sinks, and zero mark on scale passes edge of tank A, start stop-watch. Read pressure in manometer tube as soon as the pressure reading becomes steady. The instant the "2000" mark on bell B reaches upper edge of tank A, the stop-watch should be stopped and time recorded. This represents the time required to force 2000 cubic centimeters of air through the sand. The time and pressure obtained as above, are to be used as described in paragraphs 22 to 24 inclusive.

*Calculation of Permeability*

The degree of permeability as determined by this test is found by employing a formula. By its use, permeability is ascertained as the volume of air per minute, per gram per square centimeter pressure, per unit volume in specimen.

Permeability equals the number of cubic centimeters of air forced through the sand specimen, multiplied by the height of the sand specimens in centimeters; and this product divided by the product of the pressure in grams, the area of the sand specimen in square centimeters, and the time in minutes. Thus

$$\text{Permeability} = \frac{\text{cm}^3 \text{ of air} \times \text{cm height of specimen}}{\text{grams pressure} \times \text{cm}^2 \text{ area of specimen} \times \text{minutes}}$$

The method of conducting the permeability test herein described calls for 2000 cubic centimeters of air to be forced through the specimen; 5.08 centimeters (2 inches) to be the height of the specimen; and 20.268 square centimeters (3.1416 sq. in.) to be the area of the specimen. These fixed quantities are therefore substituted as constants in an equation as follows:

$$Permeability = \frac{2000 \times 5.08}{20.268 \times grams\ pressure \times minutes}$$

Reduced to its simplest terms this equation reads:

$$Permeability = \frac{501.2}{grams\ pressure \times minutes}$$

### FACTORS INFLUENCING PERMEABILITY

Of the several factors influencing permeability, the most important is the size-grade distribution. Maximum permeability is obtained with well-sorted sand and the permeability is lowered by the addition of finer size grades, the decrease being more marked the finer the admixture. Silt (—270-mesh) is the most important size grade influencing permeability, for a small amount of silt greatly reduces the permeability of sand.

The clay and moisture contents of the sand also affect permeability. If the clay is well distributed over the sand grains, an unnecessarily high bond strength may be obtained in company with low permeability. It is quite possible, with the same amount of clay, to have both a satisfactory bond strength and a sufficient permeability, by varying the mixing of the sand or by changing the moisture content. And a sand which is weak but very permeable may be milled until the clay is evenly distributed, when it will have satisfactory strength and still retain sufficient permeability.

## Dye Adsorption

### VALUE OF TESTING

"The application of the dye adsorption phenomenon to molding sand is solely for the purpose of ascertaining the nature of the clay substance present. Different sands possess widely different adsorption capacities, and this difference is due exclusively to the quantity of colloidal material present. The colloids in molding sands are mostly of an inorganic nature; hydrated aluminum silicate, hydrated iron oxide, hydrated silicic acid and other hydrated minerals. All of these constituents are of a gelatinous and sticky nature and they impart to the sand the property of bond. Strongly bonded molding sands commonly possess clay substance that is high in colloid content as measured by the dye adsorption test. The weaker bonded sands generally show a lower dye adsorption figure corresponding to the smaller quantity of colloids present in the clay substance of those sands."[1]

### STANDARD DYE ADSORPTION TEST[1]

*Procedure*

1. Twenty-five grams of molding sand, dried for 1 hour at a temperature which shall not be lower than 105 degrees Centigrade nor higher than 110 degrees Centigrade, are weighed

[1]Op. cit.

into a 500 cubic centimeter wide-mouth bottle fitted with a glass stopper, and 300 cubic centimeters of distilled water, plus 5 cubic centimeters of 10 per cent ammonium hydrate, are added. The bottle is then stoppered, sealed with paraffin wax, and rotated in a suitable machine for 30 minutes (any machine such as that used in the Standard Fineness Test, making approximately 60 revolutions per minute and up-ending the bottle with

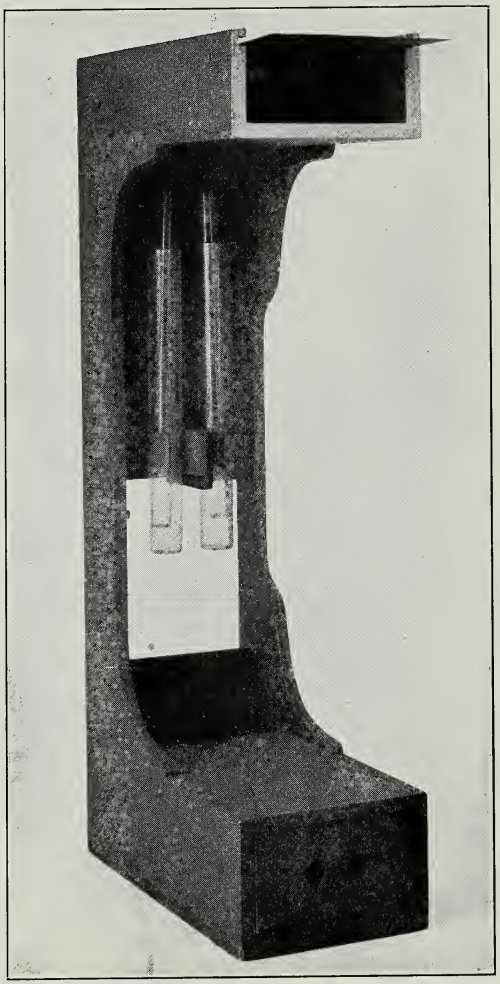


FIG. 12.—Color comparison tube holder with tubes in place.

each revolution, is satisfactory). At the end of this period 90 cubic centimeters of distilled water are added, plus 5 cubic centimeters of 10 per cent acetic acid. Crystal violet dye is then added in sufficient weight to allow for the adsorption by the colloidal matter and leave a slight excess. For molding sands of weak bond, 0.125 grams of dye is a good amount to start with; while the stronger sands require an addition of 0.150-0.300 grams or more of dye. After adding the crystal violet the bottle is sealed again and rotated for another 30-minute period. If all the dye is taken up by the colloidal matter, more should

be added, as it is necessary that an excess of dye be present over that required to satisfy the adsorption capacity of the colloids.

2. In order to determine the amount of dye adsorbed by the sand it becomes necessary to find the quantity unadsorbed or held in solution. If the test is allowed to stand over night, suspended material settles out, leaving a clear solution of the dye, and the dye unadsorbed can be determined by color comparison. The standard color solution is made up by dissolving 0.500 grams of crystal violet in 500 cubic centimeters distilled water. Twenty-five cubic centimeters of the clear dye solution are taken from the test by a pipette and run into one of a pair of "carbon" comparison tubes, such as are used in steel analysis (as shown in the illustration of a colorimeter (fig. 12) diluted to 50 cubic centimeters and thoroughly mixed. Forty cubic centimeters or more of distilled water are added to the second comparison tube, and the standard dye solution added from a burette until the color matches that of the test in question, taking care that the final volume is the same in both tubes. If it required 2.5 cubic centimeters (0.0025 grams) in the standard tube to match the color in the test, then we have 0.0025 grams of dye unadsorbed in 25 cubic centimeters or 0.040 grams in 400 cubic centimeters. This figure is subtracted from the amount of dye added to the test, multiplied by 4, and the result expressed as milligrams of dye adsorbed per 100 grams of sand.

*Notes*

*Electrolyte.* The presence of ammonium acetate in the test is helpful in that its presence tends to bring about rapidly the subsidence of the fine particles which otherwise would remain in suspension. It has no serious effect on crystal violet. The addition of ammonium hydrate acts as a partial deflocculator and thereby breaks up the agglomerations of clay or other bonding substances.

*Dye.* Only the highest grade of crystal violet should be used. Impure dye gives low figures and is unstable. Standard dye solution should be kept in the dark, and a fresh quantity should be prepared frequently.

*Used Sands.* The dye adsorption test cannot be relied upon for all grades of used sands. Impurities present in some heap sands, as for example, sea-coal, iron scale, organic binders, etc. seriously affect the adsorption results.

*Dye Concentration.* The final concentration of crystal violet should be not less than 0.024 grams, or more than 0.060 grams, in 400 cubic centimeter volume. A greater excess of dye gives high reading. After making a few tests it is a simple matter to judge the density of the clear dye solution, and it is essential that the proper concentration is obtained before the test settles overnight.

RESULTS

Dye adsorption tests were made by Mr. W. M. Saunders on 135 molding sands. These data are included in Tables 30 and 31, Chapter VI.

## Base Permeability

### FUNCTION

Base permeability is the permeability of only the sand grains of a natural-bonded molding sand. Hence, it is affected only by the factor of size-grade distribution. Its importance lies in the fact that as the clay is burned from a molding sand heap, the sand grains are left and upon the addition of new sand the size-grade distribution is changed. For example, if a sand has a high silt content, and the sand and silt, plus the burnt-out clay, are put back into the heap and new sand containing the original percentage of silt plus clay is added, the silt percentage increases.

In actual practice the new sand added is usually a sand with a high percentage of clay, but which contains also much silt. This increases the rate of silt accumulation and its attendant lowering of permeability.

### STANDARD BASE PERMEABILITY TEST

Approximately three hundred grams of sand are treated in the same manner as for the fineness test, in order to eliminate the clay. The dried sand is poured through a funnel into a two-inch glass tube, upon which is a mark indicating the volume of sand that forms a two-inch column when rammed in the permeability cylinder. The quantity of sand necessary varies slightly with certain sands according to their degree of compaction. A screen, 200-mesh for fine samples and 100-mesh for coarser samples, is used in the end of the permeability cylinder. The sand in the glass tube must be examined for bedding into laminæ of various-sized grains, particularly the silt, the relative amount of lamination indicating the difficulty involved in obtaining a uniform mix of all grades. The sand is poured evenly from the glass tube into the permeability cylinder. Some sorting is inevitable with some sands and experience will teach a rate of pouring that will minimize this error. Care must be taken not to jar or "shake down" the sample before ramming. A screen on the upper surface is advisable. The permeability is obtained by the standard method, already described. The sand is returned to the original receptacle and another sample, taken from the remixed total sample, is tested. Sorting of grain sizes by pouring the sand into the cylinder is a serious difficulty and may produce a silt layer which is more impermeable than the sample as a whole. A check as definite as is obtained in natural permeability tests is seldom possible, if the same tolerance of height of sand cylinder is used. At least five runs should be made to obtain a fair average.

### FACTORS DETERMINING BASE PERMEABILITY

#### SIZE GRADE DISTRIBUTION

The influence of size grade distribution upon base permeability is shown in Table 8. It is clear that the rate of decrease of base permeability is progressively greater the finer the admixture. It is no less clear that once the base permeability is reduced by the presence of fine material, it can not be materially increased except by addition of a large proportion of coarse sand.

#### SAND-SILT MIXTURE

Table 9 shows the reduction in permeability of 70-mesh sand by admixture of silt. The amount of reduction is progressively less with the increase in proportion of silt until finally further admixture fails to reduce the permeability. This is probably due to "saturation" or the filling of all interstices with silt. The further addition of silt beyond the limit shown in Table 9 resulted in the formation of layers of silt within the sand. Figures 13 and 14 are microphotographs of the sand and silt used in this test.

SHAPE OF GRAIN

The influence of shape of grain on base permeability is relatively unimportant. Ottawa silica sand, made up of well-rounded grains; sand from Albany molding sands, reputed to be very angular; and a mixture

TABLE 8.—*Base permeability of mixtures of various size grades*

| Mesh | | | | | Base permeability |
|---|---|---|---|---|---|
| On 40 | On 70 | On 100 | On 200 | −270 | |
| *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | |
| .... | 100.0 | ..... | ..... | .... | 236.7 |
| .... | ..... | 100.0 | ..... | .... | 56.8 |
| .... | ..... | ..... | 100.0 | .... | 25.8 |
| .... | 50.0 | 50.0 | .... | .... | 82.7 |
| .... | ..... | 50.0 | 50.0 | .... | 29.4 |
| .... | 33.0 | 33.0 | 33.0 | .... | 32.8 |
| .... | 25.0 | 25.0 | 25.0 | 25.0 | 6.7 |
| 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 8.9 |
| 14.3 | 42.8 | 14.3 | 14.3 | 14.3 | 19.2 |

TABLE 9.—*Base permeabilities of mixtures of sand (70-mesh) and silt (−270-mesh)*

| On 70-mesh | −270-mesh | Base permeability |
|---|---|---|
| *Per cent* | *Per cent* | |
| 100.0 | .... | 236.7 |
| 96.8 | 3.2 | 165.7 |
| 93.7 | 6.3 | 96.0 |
| 90.9 | 9.1 | 79.1 |
| 88.3 | 11.7 | 58.1 |
| 85.6 | 14.4 | 27.8 |
| 83.4 | 16.6 | 21.4 |
| 81.1 | 18.9 | 20.1 |

of twenty Illinois molding sands, which appeared as angular as the corresponding size grade of Albany, were used in the tests (see fig. 13 and figs. 15 to 19). Each average represents ten trials of five samples (Table 10). The round grains give the highest base permeability in all grades except 70-mesh. The permeability of Albany and the Illinois mixture are of the same degree excepting the 200-mesh grade, in which the Albany is much lower. It is probable that Illinois natural-bonded molding sands do not have sufficient grain-shape variations, one sand with another, to cause differences in base permeability.

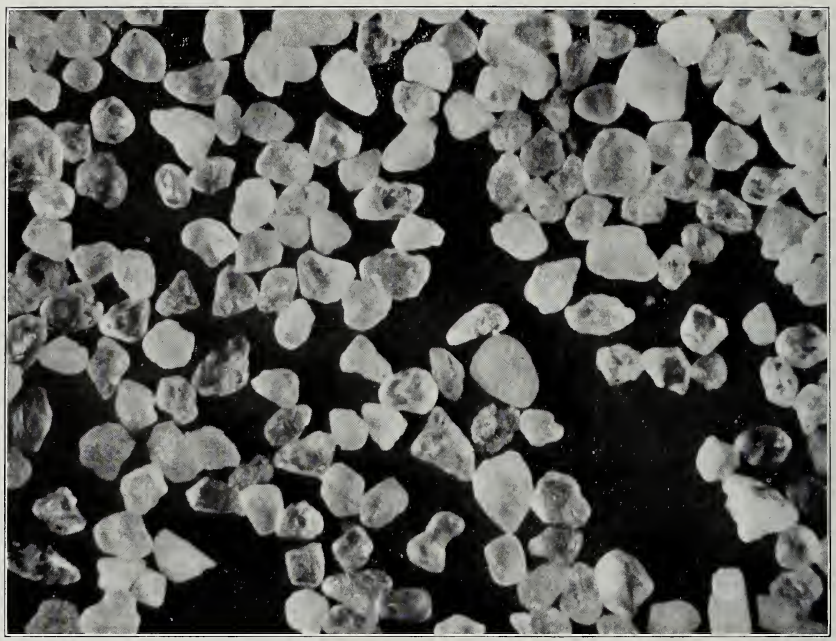


FIG. 13.—Microphotograph (x24) of 70-mesh size grade separate of a mixture of twenty Illinois sands. This size grade separate was used in obtaining base-permeability data given in Tables 9 and 10.

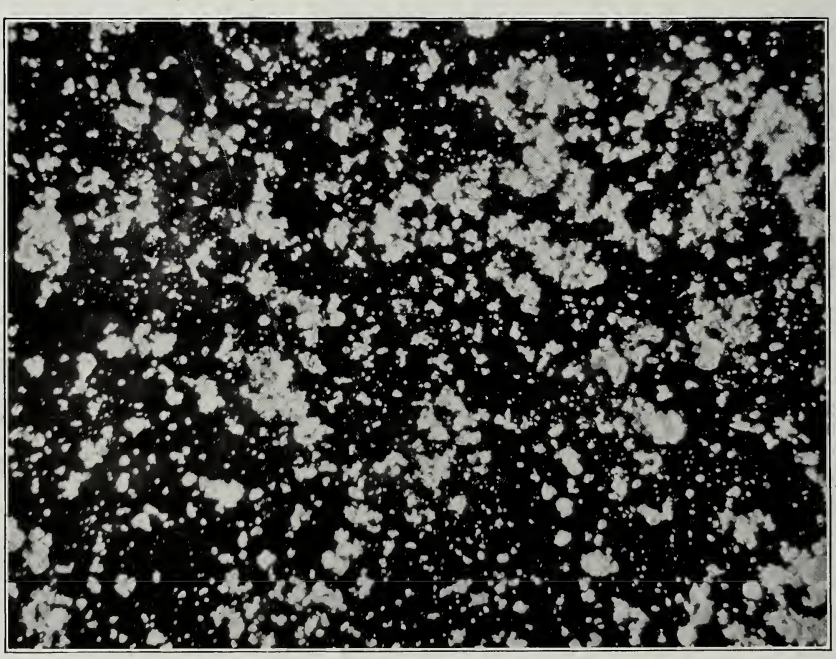


FIG. 14.—Microphotograph (x24) of silt of −270-mesh size grade, used in obtaining base-permeability data given in Table 9.

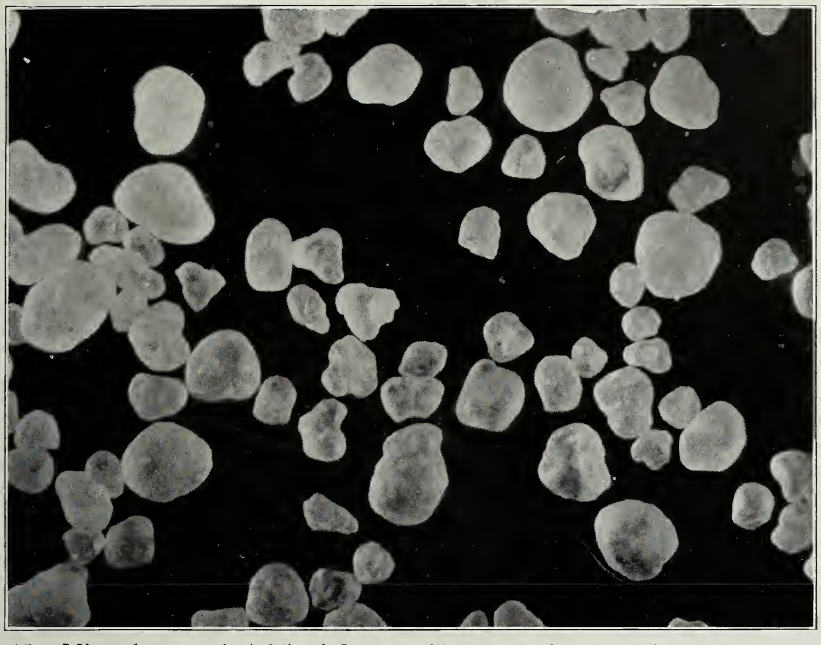


FIG. 15.—Microphotograph (x24) of Ottawa silica sand of 40- and 70-mesh size grades. The 70-mesh size grade was used in obtaining base-permeability data given in Table 10.

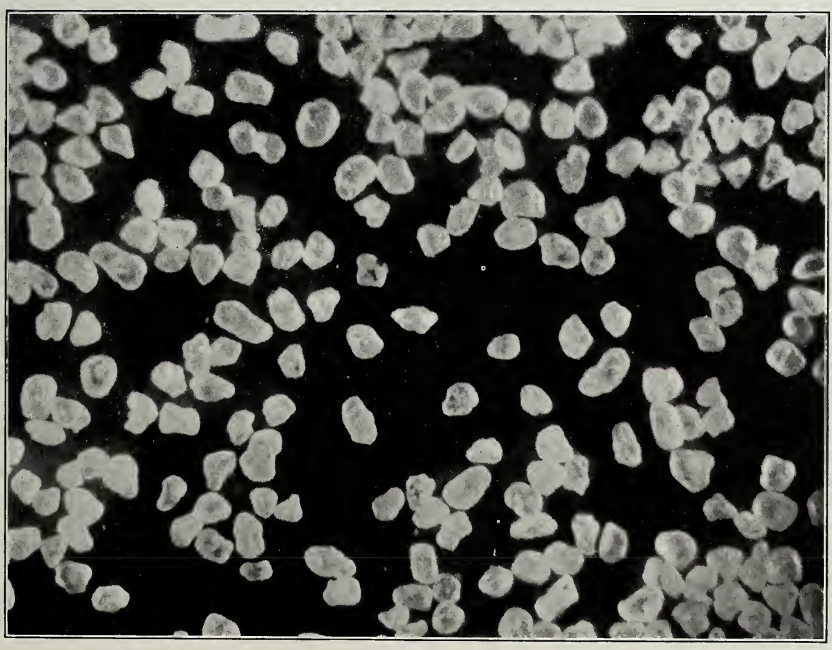


FIG. 16.—Microphotograph (x24) of Ottawa silica sand of 100-mesh size grade used in obtaining base-permeability data given in Table 10.

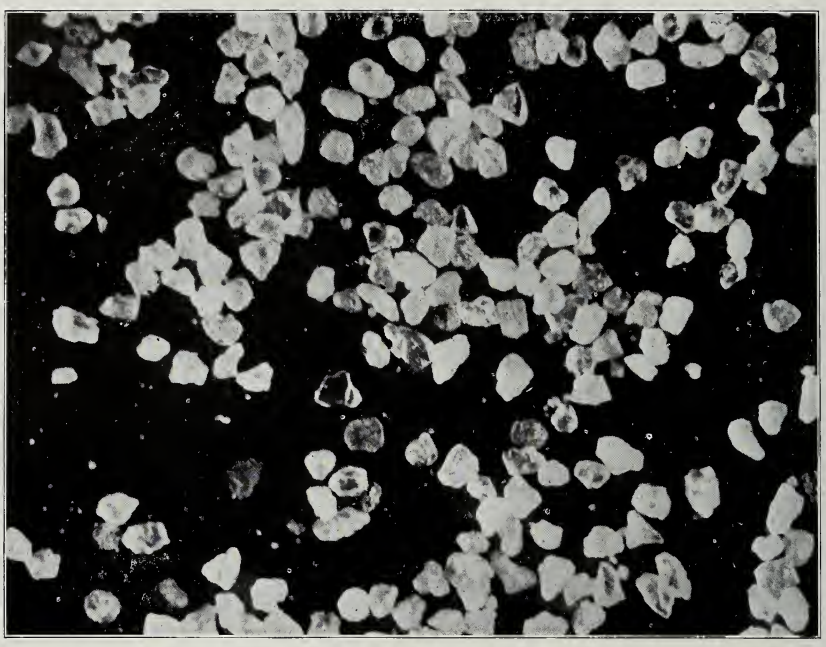


FIG. 17.—Microphotograph (x24) of Albany sand of 100-mesh size grade used in obtaining base-permeability data given in Table 10.

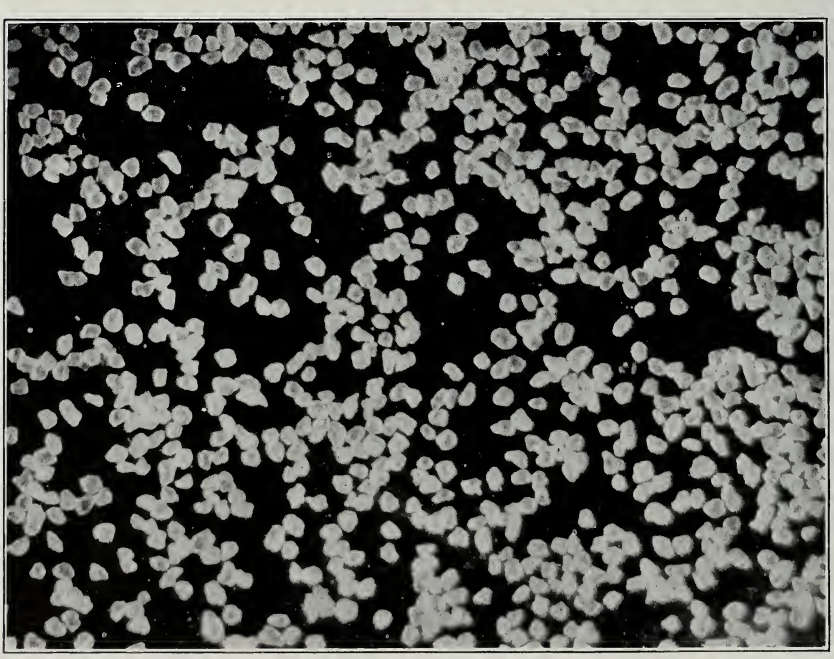


FIG. 18.—Microphotograph (x24) of Ottawa silica sand of 200-mesh size grade used in obtaining base-permeability data given in Table 10.

## Relation of Relative Fineness to Bond Strength and Permeability

It is recognized that the relative fineness of a sand has a distinct relation to physical properties. Table 11 shows the average bond strength and permeability of sands grouped according to the size grade of highest percentage. The bond strength decreases with decrease in fineness down to 200-mesh and then rises to a maximum in those samples having their clay grade higher in percentage than any other single grade. The anomaly of the high bond strength of the 140-mesh group is due to too few samples;

Fig. 19.—Microphotograph (x24) of a 200-mesh size.grade separate of a mixture of twenty Illinois sands. This was used in obtaining base-permeability data given in Table 10.

if the 100-and 140-mesh groups had been averaged together, a more representative figure would have been obtained. Both natural and base permeabilities decrease to the −270-grade, and increase at the clay grade.

## Relation of Relative Fineness to Optimum Water Content

The relation of relative fineness to the optimum water content is shown in Table 12. The tests show that those sands with the maximum size-grade percentage on 200 mesh or above, have maximum bond strength and permeability when the water content is from 4 per cent to 6 per cent, and that sands with maximum size grade percentage of silt (−270 mesh) or clay grades, tend to maximum development of these properties between 6 per cent and 8 per cent.

TABLE 10.—*Base permeability of size grades, with grains of contrasting shapes.*

| Size grade | Base permeability | | |
|---|---|---|---|
| | Ottawa silica | Albany | Mixture of grains from 20 Illinois sands |
| 70 | 228.7 | .... | 236.7 |
| 100 | 84.3 | 60.4 | 56.8 |
| 140 | 53.1 | 50.1 | 44.2 |
| 200 | 32.7 | 14.9 | 25.8 |

TABLE 11.—*Average bond strength and permeability of samples of same maximum size grade*

| Size grade of maximum percentage | Number of samples | Bond strength | | | Permeability | | | Base permeability |
|---|---|---|---|---|---|---|---|---|
| | | Per cent water | | | Per cent water | | | |
| | | 4 | 6 | 8 | 4 | 6 | 8 | |
| 40 | 1 | 273.8 | 249.6 | 233.6 | 208.8 | 156.6 | 104.4 | 113.4 |
| 70 | 44 | 265.2 | 263.5 | 238.8 | 82.7 | 67.7 | 49.0 | 71.2 |
| 100 | 9 | 233.9 | 202.5 | 174.0 | 44.2 | 37.8 | 31.7 | 31.7 |
| 140 | 3 | 264.6 | 255.9 | 218.5 | 37.4 | 38.1 | 29.4 | 31.7 |
| 200 | 5 | 212.2 | 198.2 | 174.1 | 26.9 | 27.9 | 24.6 | 27.1 |
| −270 | 46 | 214.3 | 222.4 | 211.6 | 10.6 | 11.0 | 10.2 | 11.2 |
| Clay | 8 | 285.1 | 270.4 | 274.8 | 38.6 | 41.0 | 32.2 | 46.5 |

## RELATION OF SIZE GRADE DISTRIBUTION TO BOND STRENGTH AND PERMEABILITY

In view of the fact that the relation of relative fineness to bond strength and permeability is rather definite it is of interest to introduce the factor of size grade distribution. Table 13 shows the average bond strength and permeability of sands grouped according to the two highest size grade percentages. The bond strength follows the same trends as shown in Table 11 and in addition, when the size grade of maximum percentage remains constant, the averages of bond strength and permeability increase with increase of size of the size grade of second-highest percentage, excepting, of course, the clay grade. This relation is very clean cut in the case of base permeability, which is effected only by size-grade distribution. Table 14, a detail of Table 13, shows base permeability only.

A further discussion of the relation of fineness, particularly size-grade distribution, to physical properties, is included in Chapter V.

TABLE 12.—*Optimum water content of samples of same maximum size grade*

| Size grade of maximum percentage | Number of samples | Bond strength | | | Permeability | | |
|---|---|---|---|---|---|---|---|
| | | Per cent water | | | | | |
| | | 4 | 6 | 8 | 4 | 6 | 8 |
| 40 | 1 | 1 | .. | .. | 1 | .. | .. |
| 70 | 44 | 21 | 17 | 6 | 27 | 13 | 4 |
| 100 | 9 | 9 | .. | .. | 6 | 3 | .. |
| 140 | 3 | 2 | 1 | .. | 2 | 1 | .. |
| 200 | 5 | 4 | 1 | .. | 2 | 3 | .. |
| −270 | 46 | 16 | 20 | 10 | 16 | 16 | 14 |
| Clay | 8 | .. | 2 | 6 | 2 | 4 | 2 |

## COLOR

The color of a molding sand is due to the degree of oxidation of the iron in the clay. Much-weathered molding sand is very red in color; less-weathered sands are yellowish-red to buff. The least oxidized are those sands which come from the soil zone, the zone of reduction. They are dark gray or black in color. Color, then, is a function of weathering and is to some degree indicative of a sand's history. Many foundrymen judge molding sands by color, and would hesitate to use a sand whose appearance differs only in color from a sand which has proved satisfactory. Among many other correlations of color with physical properties, it is well known that sands from the same locality are commonly the same color; that red sands are generally heavy sands with a sticky bond; and that light yellow sands are likely to burn on. A few of these adages are prejudices or opinions, but many are true, and some are so old that the reason has been forgotten.

## REFRACTORINESS

Refractoriness is resistance to heat, the degree of which is determined by the melting point. Lack of refractoriness expresses itself in "burning on," or the fluxing of sand and its inclusion in the casting and in pits on the casting surface. These two effects are due to different manifestations of lack of refractoriness. "Burning on" arises from the actual fluxing of the clay and fine silt, for these finer size grades tend to melt more readily because of their small size. Pits on the casting surface are caused by the fluxing of grains of a given mineral, commonly calcium carbonate, which burns out at a relatively low temperature. The tendency of the clay and fine silt to melt is probably due not only to their small size but to their chemical composition as well. Such lack of refractoriness may be determined only by test. Most natural-bonded sands have sufficient refractori-

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TABLE 13.—*Average bond strength and permeability of samples grouped according to the two size grades of highest percentage.*

| Size grade of highest percentage | Size grade of second highest percentage | Number of samples | Bond strength | | | Permeability | | | Base permeability | Size grade of highest percentage | Size grade of second highest percentage | Number of samples | Bond strength | | | Permeability | | | Base permeability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Per cent water | | | Per cent water | | | | | | | Per cent water | | | Per cent water | | | |
| | | | 4 | 6 | 8 | 4 | 6 | 8 | | | | | 4 | 6 | 8 | 4 | 6 | 8 | |
| 70 | 40 | 3 | 288.8 | 296.9 | 243.9 | 276.9 | 211.9 | 121.2 | 244.8 | 40 | 70 | 1 | 273.8 | 249.6 | 233.6 | 208.8 | 156.6 | 104.4 | 113.4 |
| 70 | 100 | 16 | 264.4 | 246.4 | 208.0 | 74.4 | 60.5 | 47.4 | 55.9 | 100 | 70 | 6 | 258.9 | 218.4 | 190.1 | 50.6 | 44.1 | 37.1 | 38.7 |
| 70 | 200 | 1 | 209.8 | 175.5 | 134.4 | 35.2 | 32.6 | 29.6 | 44.3 | 200 | 70 | 0 | | | | | | | |
| 70 | −270 | 3 | 223.4 | 242.1 | 244.8 | 17.5 | 23.4 | 19.1 | 17.5 | −270 | 70 | 1 | 181.5 | 197.8 | 173.8 | 13.2 | 13.0 | 12.6 | 11.3 |
| 70 | Clay | 21 | 277.8 | 286.2 | 271.9 | 75.7 | 67.5 | 49.5 | 68.8 | Clay | 70 | 2 | 308.8 | 314.2 | 332.7 | 71.9 | 82.7 | 59.1 | 114.8 |
| 100 | 70 | 6 | 258.9 | 218.4 | 190.1 | 50.6 | 44.1 | 37.1 | 38.7 | 70 | 100 | 16 | 264.4 | 246.4 | 208.0 | 74.4 | 60.5 | 47.4 | 55.9 |
| 100 | 140 | 1 | 186.1 | 161.7 | 132.9 | 30.6 | 29.5 | 24.4 | 26.2 | 140 | 100 | 2 | 292.7 | 282.7 | 236.2 | 46.0 | 48.4 | 36.1 | 37.3 |
| 100 | 200 | 0 | | | | | | | | 200 | 100 | 1 | 291.1 | 253.4 | 224.2 | 30.0 | 30.9 | 28.4 | 27.8 |
| 100 | −270 | 2 | 183.1 | 175.2 | 146.4 | 21.3 | 23.8 | 19.1 | 13.5 | −270 | 100 | 10 | 220.7 | 206.6 | 188.0 | 14.9 | 14.1 | 12.4 | 14.6 |
| 100 | Clay | 0 | | | | | | | | Clay | 100 | 3 | 312.7 | 298.1 | 295.9 | 36.2 | 32.2 | 24.7 | 30.0 |
| 140 | 70 | 0 | | | | | | | | 70 | 140 | 0 | | | | | | | |
| 140 | 100 | 2 | 292.7 | 282.7 | 236.2 | 46.0 | 48.4 | 36.1 | 37.3 | 100 | 140 | 1 | 186.1 | 161.7 | 132.9 | 30.6 | 29.5 | 24.4 | 26.2 |
| 140 | 200 | 1 | 208.6 | 202.2 | 183.3 | 20.2 | 17.4 | 15.9 | 20.5 | 200 | 140 | 4 | 194.9 | 184.4 | 161.6 | 26.1 | 27.1 | 23.9 | 26.9 |
| 140 | −270 | 0 | | | | | | | | −270 | 140 | 2 | 186.7 | 202.0 | 191.1 | 14.5 | 14.7 | 14.5 | 15.0 |
| 140 | Clay | 0 | | | | | | | | Clay | 140 | 0 | | | | | | | |
| 200 | 70 | 0 | | | | | | | | 70 | 200 | 1 | 209.8 | 175.5 | 134.4 | 35.2 | 32.6 | 29.6 | 44.3 |
| 200 | 100 | 1 | 291.1 | 253.4 | 224.2 | 30.0 | 30.9 | 28.4 | 27.8 | 100 | 200 | 0 | | | | | | | |
| 200 | 140 | 4 | 194.9 | 184.4 | 161.6 | 26.1 | 27.1 | 23.9 | 26.9 | 140 | 200 | 1 | 208.6 | 202.2 | 183.3 | 20.2 | 17.4 | 15.9 | 20.5 |
| 200 | −270 | 0 | | | | | | | | −270 | 200 | 9 | 206.6 | 201.7 | 191.5 | 11.7 | 11.9 | 11.7 | 13.5 |
| 200 | Clay | 0 | | | | | | | | Clay | 200 | 0 | | | | | | | |
| −270 | 70 | 1 | 181.5 | 197.8 | 173.8 | 13.2 | 13.0 | 12.6 | 11.3 | 70 | −270 | 3 | 223.4 | 242.1 | 244.8 | 17.5 | 23.4 | 19.1 | 17.5 |
| −270 | 100 | 10 | 220.6 | 206.6 | 188.0 | 14.9 | 14.1 | 12.4 | 14.6 | 100 | −270 | 2 | 183.1 | 175.2 | 146.4 | 21.3 | 23.8 | 19.1 | 13.5 |
| −270 | 140 | 2 | 186.7 | 202.0 | 191.1 | 14.5 | 14.7 | 14.5 | 15.0 | 140 | −270 | 0 | | | | | | | |
| −270 | 200 | 9 | 206.6 | 201.7 | 191.5 | 11.7 | 11.9 | 11.7 | 13.5 | 200 | −270 | 0 | | | | | | | |
| −270 | Clay | 22 | 222.3 | 241.2 | 233.6 | 8.6 | 9.3 | 8.5 | 8.6 | Clay | −270 | 1 | 181.2 | 207.9 | 219.2 | 3.9 | 7.4 | 9.4 | 6.5 |
| Clay | 70 | 2 | 308.8 | 314.4 | 332.7 | 71.9 | 82.7 | 59.1 | 114.8 | 70 | Clay | 21 | 277.8 | 286.2 | 271.9 | 75.7 | 67.5 | 49.5 | 68.8 |
| Clay | 100 | 3 | 312.7 | 298.1 | 295.9 | 36.2 | 32.2 | 24.7 | 30.0 | 100 | Clay | 0 | | | | | | | |
| Clay | 140 | 1 | | 299.6 | 306.1 | 31.3 | 35.7 | 34.3 | 31.2 | 140 | Clay | 0 | | | | | | | |
| Clay | 200 | 0 | | | | | | | | 200 | Clay | 0 | | | | | | | |
| Clay | −270 | 1 | 181.2 | 207.9 | 219.2 | 3.9 | 7.4 | 9.4 | 6.5 | −270 | Clay | 22 | 222.3 | 241.2 | 233.6 | 8.6 | 9.3 | 8.5 | 8.6 |

TABLE 14.—*Average base permeability of samples grouped according to the two size grades of highest percentage*

| Size grade of highest percentage | Size grade of second-highest percentage | | | | | | |
|---|---|---|---|---|---|---|---|
| | 40 | 70 | 100 | 140 | 200 | −270 | Clay |
| 40 | ..... | 113.4 | .... | .... | .... | .... | .... |
| 70 | 244.8 | ..... | 55.9 | .... | 44.3 | 17.5 | 68.8 |
| 100 | ..... | 38.7 | .... | 26.2 | .... | 13.5 | .... |
| 140 | ..... | ..... | 37.3 | .... | 20.5 | .... | .... |
| 200 | ..... | ..... | 27.8 | 26.9 | .... | .... | .... |
| −270 | ..... | 11.3 | 14.6 | 15.0 | 13.5 | .... | 8.6 |
| Clay | ..... | 114.8 | 30.0 | 31.2 | .... | 6.5 | .... |

ness for gray-iron use, at 1800° F. In Illinois the presence of calcium carbonate depends largely upon the degree of weathering of the sand, as all unweathered sands derived from glacial material contain calcium carbonate. The color of the sand is a fair index of the presence of calcium carbonate, the deep red sands being free of lime, and the lighter-colored sands containing quantities of lime, either in grains or disseminated throughout.

## Chemical Composition

No chemical analyses were made for this report. A qualitative test, the application of a few drops of hydrochloric acid to the sand, was made for free calcium carbonate and those samples which gave a positive reaction were listed as calcareous.

It seems apparent that a statement of the physical properties of a sand, in terms of Standard Tests, is of more value to the foundryman than a chemical analysis, as the specific property in which the sand is deficient may be shown by physical tests. Tests for refractoriness are necessary to gauge the refractoriness of the sand as the CaO (calcium oxide) of the chemical analysis does not necessarily mean free $CaCO_3$ (calcium carbonate). The correct interpretation of a chemical analysis of a molding sand is a matter for an expert.

# CHAPTER III—ORIGIN AND GEOLOGY OF MOLDING SANDS

## Practical Value of Geologic Study

The geology of molding sand deposits should be of interest to both the sand producer and the foundryman for the reason that the physical properties of a sand and its bond are dependent upon the manner of deposition and the degree of weathering of the deposit from which it comes.

It is not to be presumed that the foundrymen, enlightened by a knowledge of the geology of a given molding sand deposit, can directly proceed to make a better casting by application of that knowledge. Rather, the understanding that there is a relation between the origin and the physical properties of molding sand should enable the foundryman to trace sand troubles more intelligently, and should lead him to an appreciation of the possibilities of deposits and of the problems which confront the sand producer.

The problem of the sand producer is to dig and market the best sand available from his deposit. The problem of the foundryman is to determine the physical properties of the sand best suited to his work and to purchase that sand as economically as possible. If the origin has definite correlation with the physical properties and the foundryman knows what physical properties are ideal for his work, tests of properly taken pit samples will indicate whether or not a suitable sand may be produced from the deposit.

## Scope of Discussion

A discussion of the geology of molding sand deposits adequate to the scope of the subject can not be included in this report. Neither the exposition of fundamental geologic principles which apply to the formation of molding sand, nor the many details of evidence, peculiar to each deposit, combinations of which serve as a basis for interpretations, can be enumerated.

## Age of Natural-Bonded Molding Sands of Illinois

The natural-bonded molding sands of Illinois are young, as geologic age is reckoned, being of glacial (Pleistocene) age.

### CONDITIONS DURING THE PLEISTOCENE PERIOD

During the Pleistocene period Illinois was invaded by four ice sheets, which successively advanced from the Canadian area, and receded. Each ice sheet brought great quantities of boulders, gravel, sand, and clay which had been picked up farther north by the slowly moving ice. As the ice melted, this material was deposited, and by the evidence of those deposits, the areal extent of each ice sheet at its farthest advance can be determined.

The melting of the ice gave rise to streams, which were laden with glacial sediments. The amount of sediment was so great in many cases that the streams partly filled their valleys with sand and gravel, not only in the glaciated areas but to a considerable distance downstream beyond the farthest advance of each sheet. This gave rise to extensive alluvial flats in wide valleys from which sediment was picked up by the wind and carried to higher elevations and deposited. During the time intervening between the invasions of the several ice sheets and also during the time since the last invasion, the streams resumed the lowering of their beds by the removal of a part of the sediment which choked their valleys. The growth of vegetation greatly reduced the areas in which movement of sediment by the wind might be accomplished.

All deposits of natural-bonded molding sand known in Illinois are related in origin directly or indirectly to the glaciation of the State. They are products of a general condition which, in its relation to the accumulation of deposits of sand, differed from present conditions only in the fact that a vastly greater quantity of sand was directly available to the streams so that their beds were thus being built up rather than cut down as at present.

## Processes of Accumulation of Natural-Bonded Molding Sand

The natural processes by which sand was transported and deposited during Pleistocene time were perhaps different in degree from those of today, but doubtless identical in principle. An outline of the processes which must have been active from time to time and to various extents in the accumulation of the natural-bonded molding sands of Illinois, is given below. The different processes and their several phases will be considered in the order outlined.

1. Disruption
   a. Mechanical
   b. Chemical
2. Transportation
   a. Glacial
   b. Fluvial
   c. Eolian
3. Deposition
   a. Glacial
   b. Fluvial
   c. Eolian

### DISRUPTION

The primary source of all sand is pre-existing rock. Disruption, or breaking down of rock, may be accomplished chemically, by decomposition and solution; or mechanically, by the breaking of rock into fragments. Chemical decomposition is most active on the rock minerals of least stable chemical composition, reducing them to an insoluble residue which is termed clay, that part which is dissolved being carried away by water.

The mechanical disruption of rock may be variously accomplished, but temperature change, which causes alternate expansion and contraction of the rock itself and of the water and ice in the pores and cracks of the rock, is one of the very important agencies. Most of the sand of the natural-bonded molding sand deposits in Illinois is a product of mechanical disruption, the grinding during transport by glacial ice being an important agency.

A large amount of the chemically less stable minerals in any sand deposit indicates that chemical decomposition was less important than mechanical disruption. Decomposition may continue in such a sand after deposition, as will be explained later.

## TRANSPORTATION

Transportation is the movement of the products of disruption. Glaciers brought sand from great distances to Illinois, streams concentrated it and carried it beyond the glaciated areas, and winds shifted such sediment as was readily available.

### SORTING EFFECT

Glaciers transport all sizes of material without sorting. Streams move gravel, sand, silt, clay and dissolved salts; but with a given velocity, they can pick up and carry sediment only up to a certain size, all larger fragments being left behind. The finer sediment can be moved by low velocities and progressively greater velocities are required to move coarser material. An ordinarily sluggish creek may pick up and carry sand during a flood; but as the flood stage subsides, only fine sand and silt will be carried, at a still lower stage only clay will be transported, and finally at low water, the stream will be clear, its velocity being too low for it to carry sufficient clay to make the water turbid. Thus, streams tend to sort sediment according to size.

The wind generally picks up and transports only sand, silt, and clay, when such material is loose, dry, and unprotected by vegetation. Its tendency to sort sediment into size grades is more pronounced than that of streams for the reason that smaller, lighter particles rise higher and are carried farther than the larger heavier particles.

## DEPOSITION

A sediment is said to be deposited when it comes to rest after having been transported. Glacial deposition is largely due to the melting of the ice releasing the enclosed sediment. Fluvial and eolian deposition is due to the decrease in the velocity of the transporting medium below that required to keep a given grain in movement.

### SORTING BY AGENTS OF DEPOSITION

*Glacial.*—Glacial deposition forms an unsorted deposit, in which sand is mixed with gravel, boulders, and clay. No molding sand is to be found in glacial deposits proper.

*Fluvial.*—Fluvial deposition tends to sort the sediment carried in suspension into size grades. If a swift stream carrying sediment gradually

decreases in velocity downstream, the coarse sand and gravel is dropped first, then progressively finer material, and finally, in almost still water, the clay is deposited. Thus, the completeness of the sorting at any one point depends upon the rate of decrease of velocity. It is clear that uniform fineness must depend upon constant conditions of deposition over a considerable time.

Of all the fluvial deposits seen, those which had the closest approach to uniform fineness throughout considerable thicknesses and over considerable areas, were the fluvial-glacial deposits of Bond and Fayette counties, which, from all evidence, were rapidly deposited by a shallow broad stream whose source was at the melting edge of an ice sheet.

The deposition of a bed of sand and clay without fine sand and silt is an impossibility. There is a remote possibility that alternate layers of sand and of clay might be deposited in such proportion that the resulting section could yield molding sand. Streams vary so greatly in velocity at the same point at different times and at nearby points at the same time that their deposits must vary in fineness in both horizontal and vertical directions.

*Eolian.*—After sediment has been picked up by the wind, its place of deposition will depend, in part at least, upon its size and weight, the light particles being blown higher and carried farther. With a certain wind velocity the coarse sand may move by short leaps, the finer sand by longer leaps, and the clay remain in suspension for long distances. The size grade which moves very slowly is concentrated in dunes, the finer material is winnowed out and carried away. Sand dunes, therefore, occur very close to a source of sand. The sand contained in a dune is well sorted and of remarkably uniform fineness. The finer windborne sediment which is removed from a flat is deposited on the slope and rim of the valley wall and on the hilltops beyond. In Illinois the prevailing winds have evidently been from west to east as both the slope mantle of sand and the hilltop loess are thicker east of the flats than west. The deposits mantling the slopes contain variable proportions of sand and silt, but most of the hilltop deposits are silt of fairly uniform fineness.

## Processes Active After Accumulation of Sands

Glaciers transport and deposit sand, silt, and clay without sorting; but streams and winds tend to deposit these different sorts of sediment separately. A stream or wind deposit which contains originally both sand and clay, must contain also the intermediate grades of fine sand and silt. As some natural-bonded molding sands are an intimate mixture of sand and clay without fine sand and silt, obviously processes additional to those already considered must operate to produce such deposits.

## Formation of Clay Bond by Weathering

After the deposition of sand, chemical disruption may again proceed, bringing about the decomposition of any minerals which are not chemically stable. The insoluble residue is left in the interstices between the grains.

In this way a deposit of well-sorted sand, originally without bond, under certain conditions of weathering may become a usable molding sand.

If the processes of disruption instrumental in producing sand grains from the original rock are largely mechanical, many of the less-stable

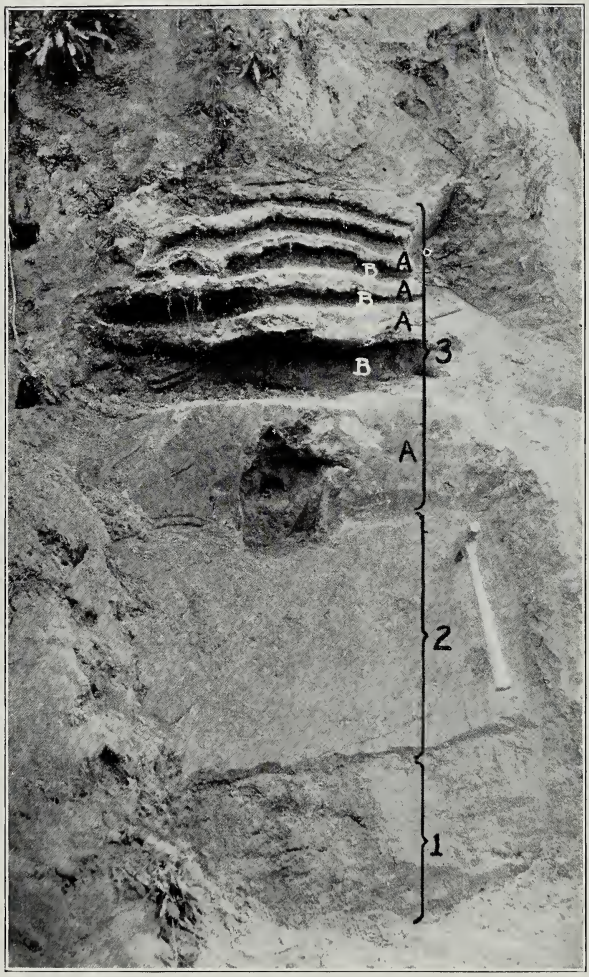



FIG. 20.—Clayey bands in sand in road cut exposure, 2¼ miles south of Homberg, Pope County. The molding sand section is numbered 3.

minerals become sand grains and are transported and deposited along with the quartz grains. After deposition of well-sorted sand, the continuance of the chemical processes of disruption results in the dissolution of the calcite, and, to some degree, the feldspar sand grains, the dissolved portion being

carried away by ground water, leaving a residue of clay between the quartz grains.

### DESCRIPTION OF CLAYEY BANDS

Such weathering action tends to produce a clayey stratum of brick-red color, friable when damp and very hard when dry. The "heavy" layer, as it is called by the molding sand producer, may be a single thick horizontally continuous layer, or it may be a series of thin horizontal layers, from an inch to a foot thick, separated by somewhat thinner layers of sharp, clean sand.

The banding, for such is its appearance when viewed in vertical section, is generally considered to be stratification due to deposition of layers of sharp sand and of clayey sand, but such is clearly not the case. Many deposits of windblown sand which are uniformly sorted from top to bottom contain clayey bands which bear no relation to depositional stratification. In some deposits several stratified layers of different fineness may be included in a single clayey band, the boundaries of which, however, in general coincide with the boundaries of the stratified layers. Figure 20 represents the banding as seen in a roadcut two and one fourth miles south of Homberg, Pope County. Four distinct layers are present, as follows:

4. Loam — reduced clay
3. Medium sand; weathered bond in bands. A is clay bands, B, sharp sand
2. Fine silty sand; some weathered bond
1. Gravelly sand with little weathered bond, but iron stained

Layers 1 and 2 are stream-terrace deposits; 3 is a windblown sand derived from the stream-terrace deposits; and 4 is soil, probably deposited by wind on a vegetated surface.

There is no relation between the thickness of the clayey bands and the total thickness of the sand in the deposit unless the total thickness of the sand pinches out to less than the thickness of the clayey bands, in which case the thickness of the banded zone is governed by that of the deposit. In a deposit of uniform fineness the clayey bands are parallel to the top of the sand deposit and in their initial stages are within a foot of the surface.

### CONDITIONS OF FORMATION OF CLAYEY BANDS

*Age of deposit.*—Of the several important conditions which govern the amount of clay present and the thickness of the bands, the length of time during which the processes of weathering have been active is the most important. Sand dunes or stream bars of recent age contain no similar clayey bands. The sand deposits of Jo Daviess, Winnebago, Boone, McHenry, Kane, Lee, Ogle, Rock Island, Bureau, Will, Hancock, Henderson, Tazewell, Sangamon, Cass, and the counties adjacent to Wabash River nowhere have a clayey layer of more than 5 feet thick and the average thickness is much less than a foot, as there are large numbers of sand deposits in which the clayey layer is not thick enough or heavy

enough to produce molding sand. The sand deposits in these counties are younger in age than the deposits in Bond and Fayette counties, in which the clayey layers range from 5 to 15 feet in thickness.

*Presence of overlying soil.*—The presence of soil on the surface of the sand deposit appears to be a contributing factor to the thickness and amount of clay present in the clayey bands. It seems possible that a part of the clay found in the clayey bands may be derived from the soil above. The protective action of the vegetable emulsoids released from the decay of vegetable matter in the soil may operate to hold clay in colloidal suspension while it is being transported by the descending surface water. The vegetable emulsoids, being unstable organic compounds, may be oxidized on reaching the sand below, causing the flocculation of the colloidal matter and the deposition of the clay. Within the clayey bands all quartz grains are coated with limonite, which grain coating is requisite to high bond strength and offers a considerable problem in the manufacture of synthetic sands. Thus, the formation of bands proceeds downwards from the surface of the sand deposit, both the clay infiltrated from the soil and the clay residual from the decomposition of the less stable grains being concentrated in the clayey bands.

*Topographic position.*—The surface elevation relative to the groundwater level is of importance in some deposits, as the clayey layer is thicker and more clayey in the more elevated parts of the deposit, the difference being more pronounced in those deposits which are geologically older.

*Process of formation.*—The details of the process resulting in the banding of a sand deposit into alternate layers of clayey sand and sharp sand are not clear, but it may be possible that the descending solution must reach a certain depth before the concentration of oxygen is sufficient to oxidize the protective colloids and cause precipitation of the colloidal clay. The upper horizontal surface of a single band is nearly plane while the lower surface is somewhat undulating with additional small projections and stringers. An impression is gained that the clay is removed from the top of the clay band and redeposited on the bottom. Certain it is that in an advanced stage the clayey layers thicken to form a single thick layer, continuous from the top downward, below which are thin layers in process of formation. Thus the fluvio-glacial sands of Bond and Fayette counties, which are the oldest deposits of natural-bonded molding sand in Illinois, contain continuous clayey layers to depths varying from 5 to 12 feet, below which are thin layers, alternating with layers of sharp sand.

## Geologic Classification of Molding Sand Deposits

The origin, or, more properly, the manner of deposition of any one molding sand deposit is the result of a combination of geologic processes and no two deposits are laid down under identical conditions. It is possible, however, to determine which process was predominantly active in the formation of any given deposit. This offers a means of classification which indicates both the topographic form and the predominating agent of deposition. Table 29, Chapter VI, is a statement of the kinds of natural-

bonded molding sand deposits found in each county and the number of producers in each.

The following is a list of kinds of deposits and the agent of deposition:

| | |
|---|---|
| Alluvial deposits | Fluvial (stream) deposits |
| Loess | Eolian (windblown) deposits |
| Slope mantles | Eolian (windblown) deposits |
| Old dunes on terraces | Eolian (windblown) deposits |
| Old dunes on upland | Eolian (windblown) deposits |
| Stream terraces | Fluvial (stream) deposits |
| Fluvio-glacial | Fluvial (stream) deposits |

## ALLUVIAL DEPOSITS

Alluvial deposits are found on flood plains of creeks and rivers. Sand suitable for molding is most likely to occur close to the river bank; the

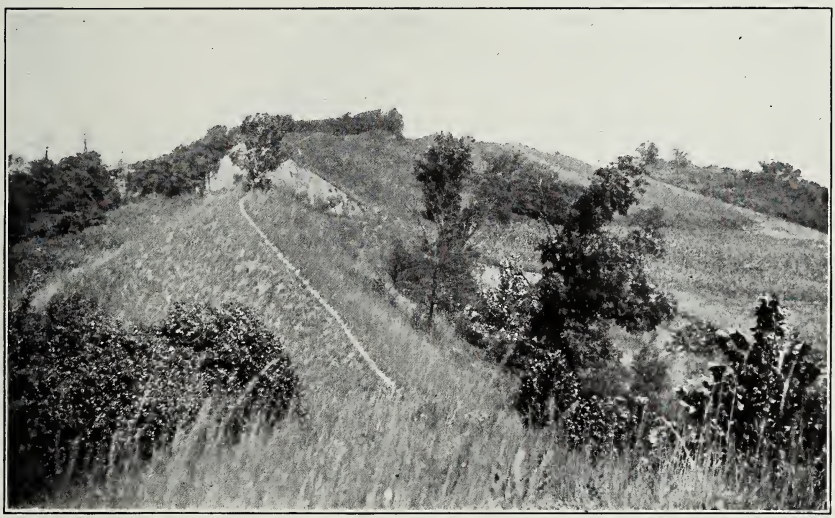


FIG. 21.—Loess ridge at crest of valley wall of Mississippi River, 2¼ miles northwest of Collinsville, Madison County.

overburden is very thin; but no generalizations can be made as to the thickness of the workable section. Alluvial deposits commonly are worked to supply only local needs. The only known production in Illinois is in Rock Island County. This kind of deposit is widespread but it can not be rated as a true molding sand and is not included in the estimate of the State's available molding sand.

## LOESS

Loess mantles a considerable portion of the area of Illinois, but in most places it is less than 10 feet thick, which is about the minimum thickness for the profitable production of molding sand.

Loess is thickest on the east rims of the valleys of the Mississippi, Illinois, and Rock rivers. In Jo Daviess, Whiteside, Hancock, and Henderson counties, workable thicknesses cap the hilltops for a distance several miles from the valley wall. In some localities, as in Madison County, loess deposits are topographically evident as a discontinuous ridge capping the crest of the valley wall. (See fig. 21.) It is commonly exposed in highway and railroad cuts in the northern counties adjacent to the Mississippi, and the counties along Illinois River.

The overburden may consist of from 1 to 3 feet of weathered loess, in which the clay is so sticky that it is unfit for molding sand. Some of the pit sections are 20 feet thick and, except on the crest of the valley wall, the fineness is relatively uniform vertically and horizontally. The upland loess at the rims of the valleys contains thin layers of coarser grains but is not of value as molding sand. All loess which is of suitable fineness for use as molding sand contains grains of lime carbonate which are of silt size or larger. Some of these are small shell fragments and others are concretions, but in either case they burn out, leaving a pitted casting surface. This lack of refractoriness prohibits extensive use of loess and reduces the importance of the extensive deposits. Loess is produced in Jo Daviess, Winnebago, Whiteside, Rock Island, Henderson, Hancock, and Adams counties, and occurs on the property of producers in Henry, Cass, Madison, and St. Clair counties, but was not being produced in 1923.

### WINDBLOWN SLOPE MANTLES

Slope mantles formed by wind are in most cases associated with loess deposits (fig. 22) and in all cases represent deposition under extremely variable conditions. The deposits occur most commonly on slopes of east valley walls of large rivers. As the material is derived from the valley flats or terraces, the most favorable location for slope-mantle deposits is just east of wide sandy stream terraces, sandy flood plains, or old lake beds. The molding sand is thickest and coarsest grained at the base of the slope and thinner and finer at higher levels. Considerable variation in fineness is inevitable, in both vertical and horizontal directions. The coarser sand normally contains some weathered bond and is consequently lime free; but the finer sands are less weathered and may even be calcareous, especially in those deposits lying on a slope capped by loess. Sand washed from the upper slope may make up a very considerable part of the thickness toward the base of the slope. Such mixture of slope wash and windblown material greatly increases the variability of the deposit. Molding sand is produced from slope-mantle deposits in Adams, Cass, Hancock Henderson, Henry, Kane, Madison, Will, and Winnebago counties, and Kendall, Lawrence, and Whiteside counties contain unworked slope-mantle deposits.

### OLD DUNES ON TERRACES

Molding sand deposits are relatively uncommon in old dunes on terraces notwithstanding the considerable total areas of terraces upon which are windblown deposits. The flatness of terrace areas gives ample opportunity for the wind to remove the soil and shift the sand about,

sorting it and depositing in low dunes. Dunes which occupy protected positions may become covered with soil so as to prevent re-working by the wind. If such dunes remain stationary long enough, the sands are weathered and clayey bands are formed, rendering the deposit suitable for molding sand. But so much time is necessary that few soil-covered dunes on terraces contain workable thicknesses of molding sand, and the maximum thickness observed was 4 feet. Although many old terrace dunes contain well-sorted sand with limonite grain coating, the clay percentage is not sufficient for adequate bond strength. Greater bond strength could be

FIG. 22.—Topography of slope-mantle deposit. Valley wall of Mississippi River, 2½ miles northwest of Collinsville, Madison County.

produced by adding clay overburden but the risk of inclusion of silt is great. The limonite-coated dune sand plus a fireclay bond would be more desirable.

Topographically the old dunes are low rounded knolls, commonly isolated, but in some places merging to form irregular ridges or slightly elevated undulating areas. Excellent examples are located on a terrace of Wabash River, two miles east of Carmi, White County. Molding sand is produced from old dunes on terraces in Peoria, Rock Island, and Will counties. Small unworked deposits occur in Henderson County and more extensive deposits in Henry, Lawrence, Pope, Tazewell, and White counties.

### OLD DUNES ON UPLANDS

Old upland dunes are most common on glacial moraines and it is probable that the sand came in most cases from adjacent outwash deposits. In all essential respects as regards suitability for molding sand, they are similar to old dunes on terraces. Many of them are not conspicuous

topographically, but appear as rounded ungullied hills. Exposures of the red clayey layers are seen in roadcuts, paralleling the surface of the sand deposits. The exposure of the edge of the molding sand may in some places be traced in a cultivated field by the prevalence of hard reddish clods from the clayey layers. Molding sand is produced from old dunes on uplands in Bureau, Fayette, Kane, and Will counties. A small unworked deposit occurs in Shelby County.

### STREAM TERRACES

The mixtures of primarily deposited sand and clay which are suitable for molding sand are rarely found in stream-terrace deposits. Mixtures of sand and silt, without the weathered clay bond necessary for the formation of molding sand, are the rule. Molding sands in stream-terrace deposits vary in fineness. It is conceivable that a deposit of uniform fineness might be laid down, but only under exceptionally uniform conditions.

Stream terraces are flats or slightly undulating surfaces of higher elevation than the flood plains of the streams. As weathering is necessary to the formation of the clayey layer, the terrace sand deposit must lie undisturbed over a long period of time if molding sand is to result. Many stream-terrace surfaces are partly covered by sharp sand being shifted by the wind, and include areas in which there are no clayey layers and other areas directly adjacent under which clayey bands occur buried by several feet of sharp sand. The finding of molding sand deposits in stream-terrace deposits which are covered by shifting sand is largely a matter of chance. Numerous hand-auger borings were made in what were considered the most likely spots on the extensive sandy terraces of both Mississippi and Illinois rivers and no workable deposits were found. Exposures of molding sand may be found in the terrace sands of Wabash and Green rivers. Jo Daviess, Kane, McHenry, and Will counties have producing deposits of this kind and unworked deposits are found in Boone, Henry, Jackson, La Salle, Marshall, Ogle, Peoria, Pope, Rock Island, and Tazewell counties.

### FLUVIO-GLACIAL DEPOSITS

Some of the deposits classified as of stream-terrace origin are undoubtedly parts of valley trains and hence might be classified as fluvio-glacial. Their classification is based upon topographic form. The deposits which are classified in this report as fluvio-glacial are contained in the fragmentary ridges which occur in Bond and Fayette counties and which are a part of a widespread system. These fragmentary ridges are termed "ridged drift" by Leverett[1] and are mapped as Illinoian in age. Concerning the texture of the material composing them he says:

"The entire system of ridges is composed largely of typical till, blue till being present in the lower portions and brown till near the surface. In a few cases gravel and sand have been found, but such material is so rare that railways have not found it expedient to obtain ballast from these ridges."

[1]Leverett, Frank, Illinois Glacial Lobe: U. S. Geol. Survey Monograph 38, p. 71, 1899.

Till is an unsorted mixture of boulders, cobbles, pebbles, sand, silt, and clay. Such was the texture of the upper 6 feet of the drift ridges examined in Madison and St. Clair counties. In Bond and Fayette counties the drift ridges are capped by 1 to 4 feet of loess (?) below which is either sandy till or well-sorted sand containing horizontal or nearly horizontal pebble or cobble bands. The sand has been weathered to such an extent that weathered clayey bands extend to a depth of 7 to 15 feet. In

FIG. 23.—Basal 3 feet of 9-foot molding sand section of fluvio-glacial material. Pit of G. Nicol and Son, Tamalco, Bond County.

those parts of the ridges where sand is found, the sand is apparently continuous as it is exposed both in ravines and on the uplands. That sand and gravel continues to a considerable depth as shown by the following well records cited by Leverett.[1]

A coal boring at Greenville, which is on a drift ridge, penetrated 204 feet of drift, all except the first 10 feet of which was sandy or gravelly. In

[1]Idem, pp. 750-753.

the vicinity of Woburn, wells on low drift ridges encountered 40 feet of gravel. Wells on the drift ridges about a mile south of Vandalia are reported to pass largely through sand.

The uniformity of the lower limit of size of the sand grains, as shown by fineness tests of sands taken from sections of several pits, implies very uniform conditions of deposition over a considerable period of time, not only in a given place, but in a number of places. The presence of nearly horizontal pebble and cobble bands (fig. 23) is indicative of a very shallow current, as pebbles and cobbles may be rolled in the shallows of an aggrading stream. The absence of lenses and pockets points to a constantly aggrading stream.

The fact that the deposits are part of a drift ridge is suggestive of morainic conditions, and the scarcity of bedded sand in other parts of the ridge perhaps indicates that the Bond and Fayette County deposits were formed by a stream which carried the englacial drainage of a considerable area. The uniformity of fineness indicates uniform conditions of deposition. Possibly deposition was by a shallow, swift, sand-choked stream.

The drift ridges (see county descriptions, Chapter VI) of Bond and Fayette counties undoubtedly contain very large supplies of molding sand of uniform fineness. The excellent sorting of the limonite-coated sand, the absence of silt, and the ample percentage of strong clay, give a combination of high permeability and bond strength which should make this sand one of the best for medium and heavy work. The thickness and uniformity of the available section simplifies production. It is not probable that extensive deposits of molding sand will be found in drift ridges in other counties.

## Relation Between Physical Properties and Origin

### FINENESS

The fineness of a deposit as a whole is dependent upon the source of the sediment, upon the prevailing velocity of the transporting agent, and upon the prevailing rate of decrease of velocity. The degree of uniformity is proportionate to the uniformity of the conditions which prevailed. The size-grade distribution of the sand of any vertical section of a deposit is in proportion to the variability of the conditions governing the deposition. Uniform conditions under which the sand is sorted will build up a deposit yielding but few grades; variable conditions, each phase of which sorts the sand, will build a deposit in which more grades are represented. Very coarse and very fine material will be absent in both cases. Uniform conditions under which poorly sorted sediments are deposited will result in a sand with a wide range of size grades, but in which the size-grade distribution is uniform throughout the section. Variable conditions in which each phase deposits a poorly sorted sediment will result in a deposit which has a variable size-grade distribution.

Table 15 shows the average fineness of Illinois molding sands grouped by origin. Fluvio-glacial, terrace-dune, and upland-dune sands are well sorted and have low silt percentages. Slope-mantle sands are not well

sorted and have a high silt percentage. Stream terrace and alluvial sands have size-grade maxima at 200-mesh, and high silt percentages. Loess averages 65 per cent silt.

## BOND STRENGTH

Bond strength is dependent upon the kind and amount of clay, the limonite coating of grains, and the surface tension of the water films surrounding crystalline grains. The amount of clay is indicated by the fineness, as is the proportion of fine crystalline grains. All other things being equal, those sands which have been longest weathered contain the

TABLE 15.—*Average fineness of groups of natural-bonded molding sands of similar origin*

| Origin | Number of samples | Size grade | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12 | 20 | 40 | 70 | 100 | 140 | 200 | 270 | −270 | Clay | Total |
| Fluvio-glacial | 14 | .7 | 1.5 | 5.6 | 37.0 | 15.4 | 7.2 | 4.6 | 1.1 | 7.5 | 18.5 | 99.1 |
| Terrace dunes | 17 | .2 | 1.3 | 5.4 | 30.3 | 16.2 | 11.3 | 9.5 | 1.9 | 6.2 | 16.7 | 99.0 |
| Upland dunes | 13 | .. | .3 | 1.6 | 30.8 | 21.5 | 10.7 | 7.8 | 2.0 | 7.4 | 17.1 | 99.2 |
| Slope mantle | 36 | .. | ... | .5 | 15.4 | 15.9 | 10.5 | 10.6 | 3.9 | 26.3 | 16.2 | 99.3 |
| Stream terrace | 22 | .. | .1 | 1.2 | 12.5 | 10.9 | 10.0 | 13.5 | 6.4 | 25.9 | 18.9 | 99.4 |
| Alluvium | 4 | .. | .. | .6 | 4.4 | 11.6 | 19.7 | 20.3 | 6.0 | 23.1 | 13.5 | 99.2 |
| Loess | 10 | .. | .. | .2 | 3.8 | 4.4 | 3.8 | 6.9 | 4.8 | 65.3 | 10.2 | 99.4 |

TABLE 16.—*Averages of bond strength, permeability and dye adsorption of Illinois natural-bonded molding sands by groups of similar origin*

| Origin | Number of Samples | Bond Strength | | | Permeability | | | Dye Adsorption | Base Permeability |
|---|---|---|---|---|---|---|---|---|---|
| | | Per cent water | | | Per cent water | | | | |
| | | 4 | 6 | 8 | 4 | 6 | 8 | | |
| Fluvio-glacial | 14 | 317.6 | 324.5 | 279.7 | 116.7 | 87.8 | 66.2 | 2206 | 100.8 |
| Terrace dunes | 17 | 264.8 | 255.6 | 221.3 | 92.6 | 73.0 | 54.2 | 2060 | 80.2 |
| Upland dunes | 13 | 265.4 | 258.1 | 231.3 | 73.2 | 66.3 | 47.0 | | 61.8 |
| Slope mantle | 36 | 229.3 | 226.1 | 213.8 | 20.3 | 20.3 | 17.4 | 1960 | 18.0 |
| Stream terrace | 22 | 204.2 | 218.3 | 217.6 | 20.0 | 21.7 | 19.3 | 1794 | 21.5 |
| Alluvium | 4 | 214.4 | 218.3 | 212.7 | 15.7 | 14.2 | 13.1 | 2634 | 16.3 |
| Loess | 10 | 199.1 | 204.5 | 194.9 | 6.1 | 6.3 | 6.3 | 1712 | 8.1 |

lowest ratio of silt to clay. There are many sands containing much silt which also contain clay derived by weathering, but if depositional conditions were such as to allow the silt to accumulate it is entirely possible that some of the clay was originally deposited, so that such sands have their clay derived from two sources. The presence of limonite-coated grains is a qualitative indication of weathering, for a deposit may have coated grains but contain very little weathered clay. In very fine sands all the clay may have been primarily deposited and, if the proportion of clay is very small, the bond strength may be largely derived from the surface tension of the water films surrounding the grains.

## DURABILITY

The relation of durability to origin probably goes back to the original source and the kind and degree of the processes of disruption. In the case

of Illinois natural-bonded molding sands there is at present no basis for distinctions in degree of durability.

### PERMEABILITY

As the degree of permeability is dependent upon the size-grade distribution of the sand and upon the amount of clay and its distribution upon the sand grains, differences in fineness must cause differences in permeability. All other things being equal, coarser sands are more permeable than fine, and of two sands of the same relative fineness, the less silty will be more permeable. The size-grade distribution being the same, the sand with the less clay will be the more permeable.

### DYE ADSORPTION

Dye adsorption tests were made by Mr. W. M. Saunders. The dye adsorption values for all sands tested are indicated in Tables 30 and 31, Chapter VI. Table 16 includes averages of the dye adsorption values of sands grouped by origin.

The qualitative correlation between the averages of the dye-adsorption values and the bond-strength values indicates the importance of the colloidal clay as a factor of bond strength. Alluvium has a high average dye-adsorption value because of the presence of organic colloids.

The quantitative relation of the dye-adsorption value to bond strength as determined by the Standard Cohesiveness test can not be accurately determined for the sands tested in this work, for the reason that three or four bond-strength values do not give adequate basis for such comparison. In general, dye-adsorption values are high for sands of high bond strength and low for sands of low bond strength, but those sands of medium bond strength show a greater range of dye-adsorption value. In order to correlate bond strength of any one sand with its dye-adsorption value, at least 10 bond-strength determinations should be made between 3 and 10 per cent water content.

### BASE PERMEABILITY

The permeability of the sand grains without the clay is even more dependent upon the size-grade distribution than is the natural permeability. In sands of the same relative fineness, the less the silt the higher the permeability.

Thus, the fineness of the sand is a comparative index of the permeability. Table 16 includes the average base permeability of each group of Illinois molding sands of similar origin.

### COLOR

As has been stated, the color of molding sand is due to degree of oxidation of iron, and is a criterion of weathering and a qualitative indication of the presence of weathered clay. By virtue of that fact it is also a criterion of one kind of refractoriness.

### REFRACTORINESS

The low refractoriness which is caused by the presence of calcium carbonate is common in molding sands derived from unweathered deposits and is absent from weathered deposits. The redness of a molding sand is indicative of refractoriness while the buff and yellow-brown molding sands are more likely to contain calcium carbonate. This is true of Illinois molding sands, all of which have been derived from glacier-borne material.

The lack of refractoriness which arises from the tendency of the fine material to fuse is governed by the original chemical character and degree of disruption of the glacial material. It can be determined only by direct test.

### PHYSICAL PROPERTIES OF SANDS OF SIMILAR ORIGIN

Considering Tables 15 and 16 together we find that the averages of fluvio-glacial sands show high bond strength and high permeability which is in accordance with the high clay percentage and the excellent sorting. The bond strength of the terrace-dune and upland-dune groups are practically the same, that of the average upland-dune sands being slightly higher, and the average clay content is also slightly greater. However, the average permeability of upland-dune sands is lower, and the size-grade distribution indicates slightly more material in the finer grades. Slope-mantle sands have low average bond strength and permeability. The sand is relatively fine with much silt, which tends to lower the bond strength, and the size grade distribution is wide, reducing the permeability. Stream-terrace and alluvial sands are similar in mode of origin and their average fineness, bond strength, and permeability are similar. The optimum water content for bond strength rises to 6 per cent in these sands, a circumstance which is normal for fine sands. The lower average permeability of the alluvial sands is due to higher percentages of the finer grades.

Loess, the finest of all, shows a low average bond strength, with maximum at 6 per cent water content; and a low permeability in keeping with the high silt content.

## Bearing of Origin on Problem of Classification

The conditions of source, transportation, and deposition govern both the relative fineness and the size grade distribution of all sediments. The uniformity of these conditions governs size grade distribution of any vertical section of a deposit. The fineness of the sand is directly determined by the conditions of origin of the deposit. The clay content may be either primarily deposited, secondarily weathered, or a combination of both which is indicated by color. If fineness is a function of origin, a classification of molding sands compatible with their origins could be made on the basis of fineness and color (see Chapter V).

# CHAPTER IV.—PROSPECTING, PRODUCING, AND MARKETING

## Introduction

The methods of locating and thoroughly prospecting molding sand deposits vary with the locality and with the kind of deposit. The topography is most important in the preliminary reconnaissance of a large area, especially if the general geology of the region be known. Some discussion of the topographic position of various kinds of deposits will be found in Chapter III. Table 29, Chapter VI, is a general analysis of the kinds of deposits found in the various counties and the probabilities of the occurrence of molding sand. In addition, the locations of known deposits of each county are given under county headings in Chapter VI.

## Factors Influencing Value of Deposits

The value of a deposit of molding sand does not depend entirely upon the quality of molding sand which it contains. Many other factors must be taken into account, some of the most important of which are distance from transportation, distance of shipping point from market, and accessibility of deposit as regards topographic position, overburden, thickness, and uniformity.

Under present conditions the margin of profit is so small that a haul of more than two miles to the shipping point is out of the question. The distance of shipping point from market is exceedingly variable, as sands are sometimes shipped great distances, provided they have exactly the quality desired. The marketing of a good sand resolves itself into a problem of distribution, facilitated by advertising, salesmanship, and a thorough knowledge of various foundry needs.

The lack of accessibility of some pits and deposits may be remedied by the building of roads or railroad sidings, but this may require so much capital that a small producer, possessed of a deposit of uncertain quality or quantity and selling to a small or uncertain market, does not feel justified in making the venture. The thickness of overburden and of the molding sand proper and the uniformity of fineness are questions to be considered in the initial prospecting of the deposit to determine the quality of sand present.

## Prospecting Methods

Possibly the best method of prospecting is to make auger borings at regular intervals, and note the thickness of overburden, the thickness of molding sand, and the depth of sharp changes in fineness. Such data can be organized and saved for reference by means of a simple large-scale map of the deposit, the distance between borings being posted and each line of borings paralleling a fence or the preceding line of borings; written notes made at the time should be numbered and corresponding numbers should be placed on the map at the points where the borings are made. Samples taken from the auger for the purpose of a fineness test should be a mixture of the sand from the total section adjudged workable. Data

from the fineness test of samples taken in that manner are hardly conclusive as to the degree of uniformity, because the small quantity obtained may not be representative. After definite data on thickness of overburden and thickness of the molding-sand layer or layers have been obtained, pits should be sunk through the supposedly workable section and a 50-pound sample obtained from each pit by mixing and quartering several hundred pounds. Care must be taken in sampling to include no top clay and to include only the workable section. Several samples, each taken from parts of the deposit which the auger showed to be the heaviest, the sharpest, the coarsest, etc., will reveal the extremes which may be encountered. A number of samples should be taken of the more uniform parts of the deposit in order to find the degree of uniformity to be expected. The Standard Test data, when studied in relation to the sample's position in the deposit, will be a fair index of the physical properties of the sand. The producer with a knowledge of the quality and quantity of his "stock" of sands should be better able to meet a specific demand or to sell a definite grade than if he had only a slight knowledge of what was behind the pit face.

## Production Methods and Equipment

### EXCAVATION

The method of removing overburden and of digging the sand is of considerable economic importance. Hand shovelling (fig. 24) is neces-

FIG. 24.—Molding sand pit in which both stripping and loading are done by hand. Jesse Westervilt pit, 1 mile east of Buda, Bureau County.

sary in most pits, because of the need for rather accurate selection of parts of the section to be included. The use of scrapers in stripping is uncommon as the sand surface must be finally cleaned of the overburden by hand shoveling and because the overburden must be spread evenly over the floor of the worked-out part of the pit, in order that the agricultural

value of the land may be retained. The Rockton Molding Sand Company of Rockton, Winnebago County, utilizes an adaptation of a gasoline-driven ditch-digging machine, which strips and digs a given section, delivering the sand to wagon (figs. 25, 26, and 27). Such a machine seems well

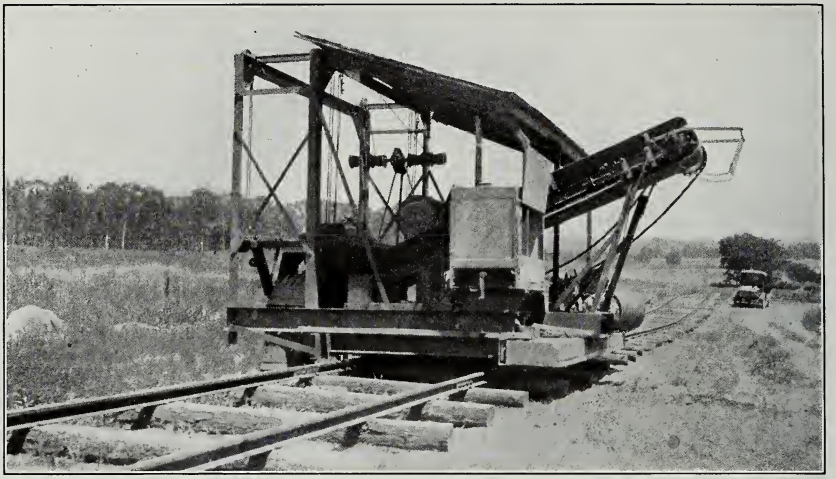


FIG. 25.—A machine for digging molding sand and delivering it to truck, Rockton Molding Sand Co., Rockton, Winnebago County.

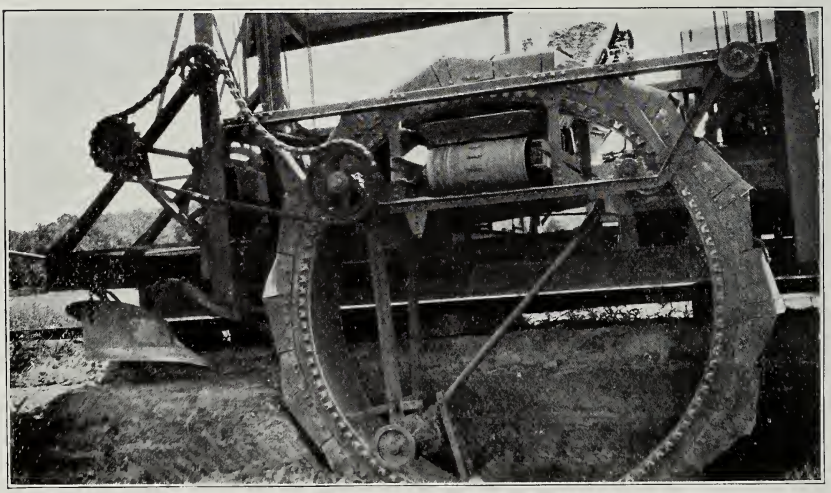


FIG. 26.—Side view of machine shown in fig. 25.

suited for the production of sand from a uniform deposit. The use of a small steam shovel for thick sections of uniform texture is entirely possible. The above-mentioned company digs loess with a shovel, using a narrow-gauge tram to transport sand to the loading dock.

### MULLING MACHINERY

Mullers designed to remove lumps and to make an intimate mixture of two sands are used by several companies. The Rockton Molding Sand Company employs a machine patented by them, which mulls the sand by means of revolving cylinders and conveys the mulled sand into the car. The C. E. Oberlaender Company of Colona, Henry County, and the Purity Molding Sand Company of Dallas, Henderson County, operate loading conveyors which mull the sand.

FIG. 27.—Pit face and replaced stripping on pit bottom. Worked by machine in figs. 24 and 25. Rockton Molding Sand Co., Rockton, Winnebago County.

## RELATION BETWEEN METHODS OF PRODUCTION AND QUALITY OF SAND PRODUCED

### METHODS OF OPERATING PIT

Because of the large number of part-time producers and because of poor marketing arrangements, methods of production are governed to great extent by temporary expediencies rather than by a policy of conservation. The methods are also governed by the degree of uniformity of the deposit. Most deposits of molding sand, being covered by soil, underlie agriculturally valuable land and the soil must be replaced after the sand is removed. This is accomplished by opening a long pit and removing the sand along the whole length before a new cut is made. The overburden is removed by hand shoveling and is thrown in the bottom of the worked-out strip. The average thickness of overburden is about a foot, as a deposit with more than two feet of overburden cannot, under present methods, be worked with profit, unless the deposit be very thick. The section of molding sand is hand-shoveled into wagons or trucks and hauled to the nearest siding. If the deposit is uniform the whole section is included. A variable deposit often necessitates the abandonment of a part of the pit face.

## MIXING

For some kinds of molding sand, sand from two or more pit sections is mixed. It is a common belief among producers that many kinds of molding sand may be produced from the same deposit, but foundrymen are of the belief that a given district containing several deposits can produce only one kind of molding sand. Both are in some measure correct, for the producer, by mixing sands of different fineness, may ship a sand which is different in fineness from the average of the deposit; but in order to do so, his deposit must be variable horizontally, and the sum of such variability from two or more pit sections, results in a molding sand which is not likely to remain uniform throughout a week of production. The foundryman must have a uniform sand, and, as a rule, the deposits of a single district are of similar origin and all the produced molding sand is of the same degree of uniformity as well as similar in appearance.

Although the mixing of molding sands from two deposits or from two parts of the same deposit may develop some certain degree of a given property which is required at the moment, the practice of mixing of molding sands, by either foundryman or producer, is not economical from the standpoint of conservation, as the gain in degree of one physical property is certain to be attended by the loss in degree of other physical properties. However, when mixing must be done, it is far better for the foundryman to do the mixing as he has the immediate object in view and needs to mix only enough for his purpose.

Deposits which contain molding sands of low bond strength are sometimes utilized by mixing some proportion of clay overburden with the sand. In Illinois the clay overburden in most cases is leached loess, and contains as high as 50 per cent silt. Silt reduces the permeability of the sand, limiting its use. Some producers unintentionally include much silt in the sand by careless methods of production.

The manner in which the sand is handled influences the bond strength through the distribution of the clay on the sand grains. Sand shoveled into a truck and then shoveled or dumped into a car is somewhat mixed but, due to the fact that some layers of a deposit may have no clay bond and other layers a heavy clay bond, the sand may be "patchy" or lumpy. Some producing companies mull their sand in a mechanical mixer to break up lumps and thoroughly mix the sand. Such machinery tends to develop the maximum bond strength with some loss to permeability. Obviously, all sands should not be so treated.

## SUMMARY

The manner of production may change the size-grade distribution of a molding sand so that the produced sand is widely different from that of a vertical section of the deposit. The usual manifestation of such a change is in an increased percentage of the silt. The change in size-grade distribution influences the physical properties of permeability and bond strength. The permeability and bond strength are also influenced by the methods of mixing.

Any classification of natural-bonded molding sands must take into consideration the variations produced by production methods.

# CHAPTER V.—CLASSIFICATION OF NATURAL-BONDED MOLDING SANDS INTO TYPES

## Basis on Fineness and Color

A classification of natural-bonded molding sands must be based upon physical properties which are requisite to its use. Divisions must be so made that few sands fall on the border lines. Sands should be easily classified, preferably by means of single tests. The terms used in statement of classification should be both simple and quantitatively accurate.

In view of the fact that fineness governs the physical properties to a large extent, and that fineness is dependent upon origin, it seems entirely logical to base a simple classification upon fineness; and, because color is a criterion of degree of weathering and hence of refractoriness, it can well be included as an additional criterion for classification.

## Types of Natural-Bonded Molding Sand Defined

### type i

Natural-bonded molding sands classified as Type I are those with maximum size grade percentage, excepting the clay grade, on or above 100-mesh; with the silt (−270-mesh) grade percentage less than one-half that of the clay; with a large proportion of the sand grains coated with limonite; and with a clay bond red to dark red in color.

This is a coarse sand, so well sorted and so relatively silt-free as to have high permeability; containing quartz grains coated with limonite, which makes for high bond strength; and containing red clay, which, as a general rule, gives high bond strength. Table 17 gives the averages of bond strength and permeability tests made on Type I sands. Figures 28, 29, and 30 relate to Type I sands.

These properties make Type I sands suitable for medium and heavy work, in which the large amount of metal poured makes necessary a mold strong enough to withstand the weight, yet open enough to give vent to the considerable volume of gases.

Table 17.—*Averages of bond strength and permeability by Types*

| Type of molding sand | Number of samples | Bond strength | | | Permeability | | | Base permeability |
|---|---|---|---|---|---|---|---|---|
| | | Per cent water | | | Per cent water | | | |
| | | 4 | 6 | 8 | 4 | 6 | 8 | |
| I | 35 | 290.2 | 282.9 | 255.4 | 105.5 | 84.9 | 59.8 | 90.2 |
| II | 35 | 208.3 | 219.2 | 212.6 | 12.4 | 12.9 | 12.1 | 13.2 |
| III*a* | 19 | 239.9 | 245.3 | 230.3 | 42.3 | 38.6 | 31.4 | 36.8 |
| III*b* | 27 | 220.1 | 219.7 | 201.7 | 18.1 | 19.0 | 16.1 | 15.1 |

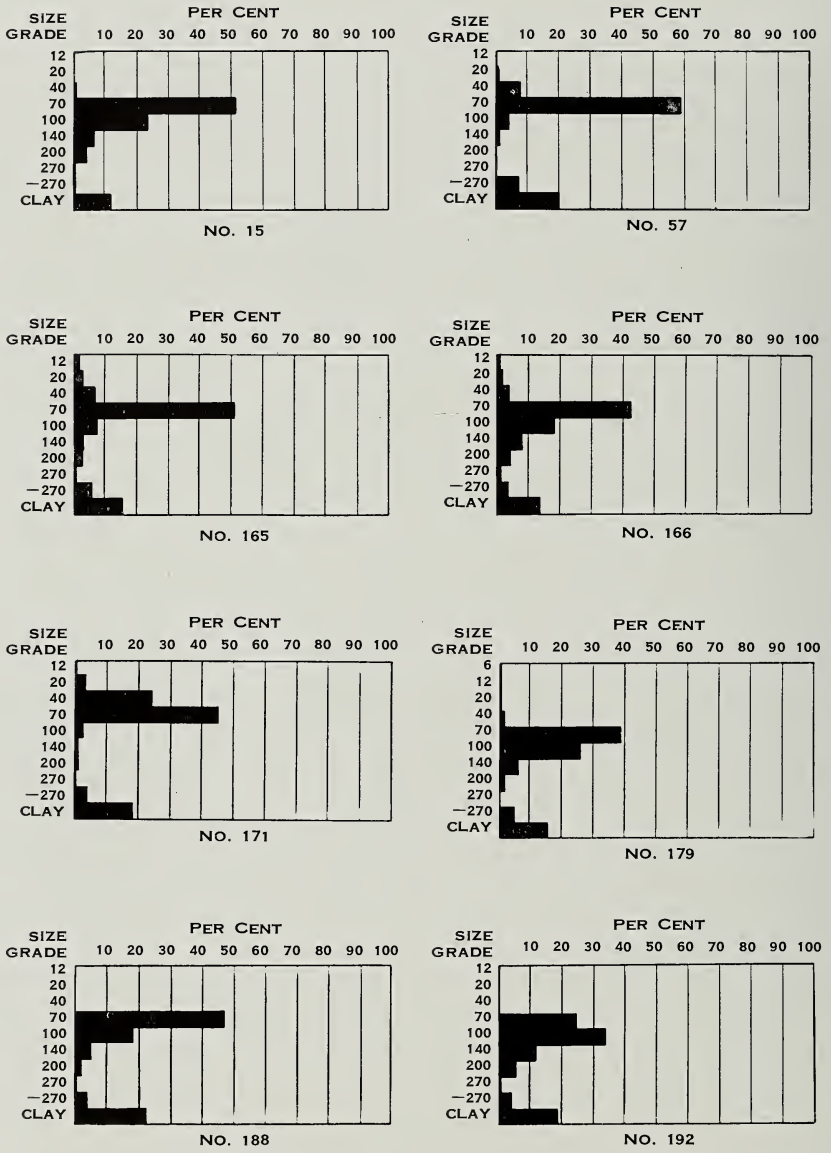
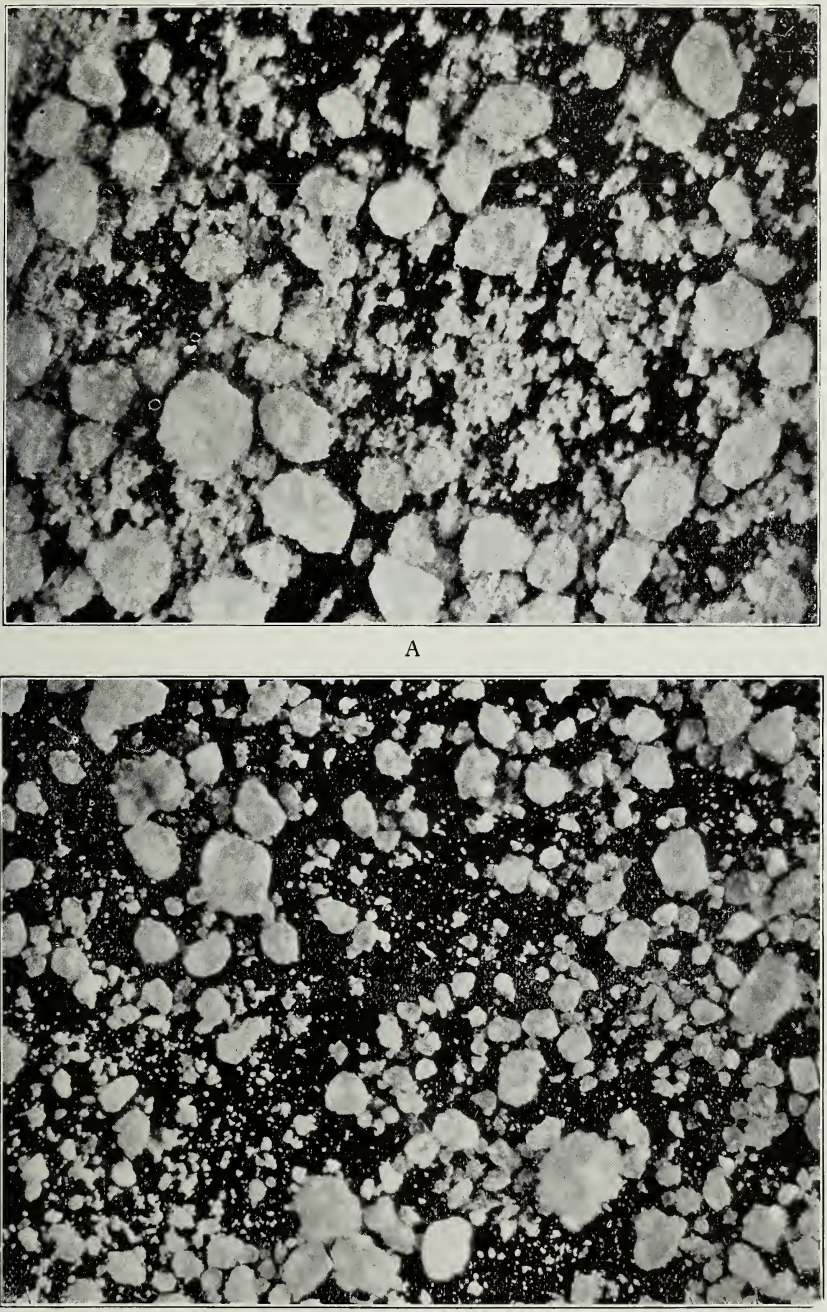



FIG. 28.—Fineness graphs of Type I sands. (See figs. 29 and 30.)

*Sample No. 15.*—Riverside Sand Co., Ritchey, Will County.
*Sample No. 57.*—Undeveloped deposit, five miles south of Oregon, Ogle County.
*Sample No. 165.*—Eugene Stultz, Vandalia, Fayette County.
*Sample No. 166.*—G. Nicol and Son, Tamalco, Bond County.
*Sample No. 171.*—Ed. B. Squier Co., Greenville, Bond County.
*Sample No. 179.*—G. Nicol and Son, Tamalco, Bond County. In use by Enterprise Foundry Co., Belleville.
*Sample No. 188.*—Undeveloped deposit, Homberg, Pope County.
*Sample No. 192.*—Undeveloped deposit, 1½ miles east of Carmi, White County.



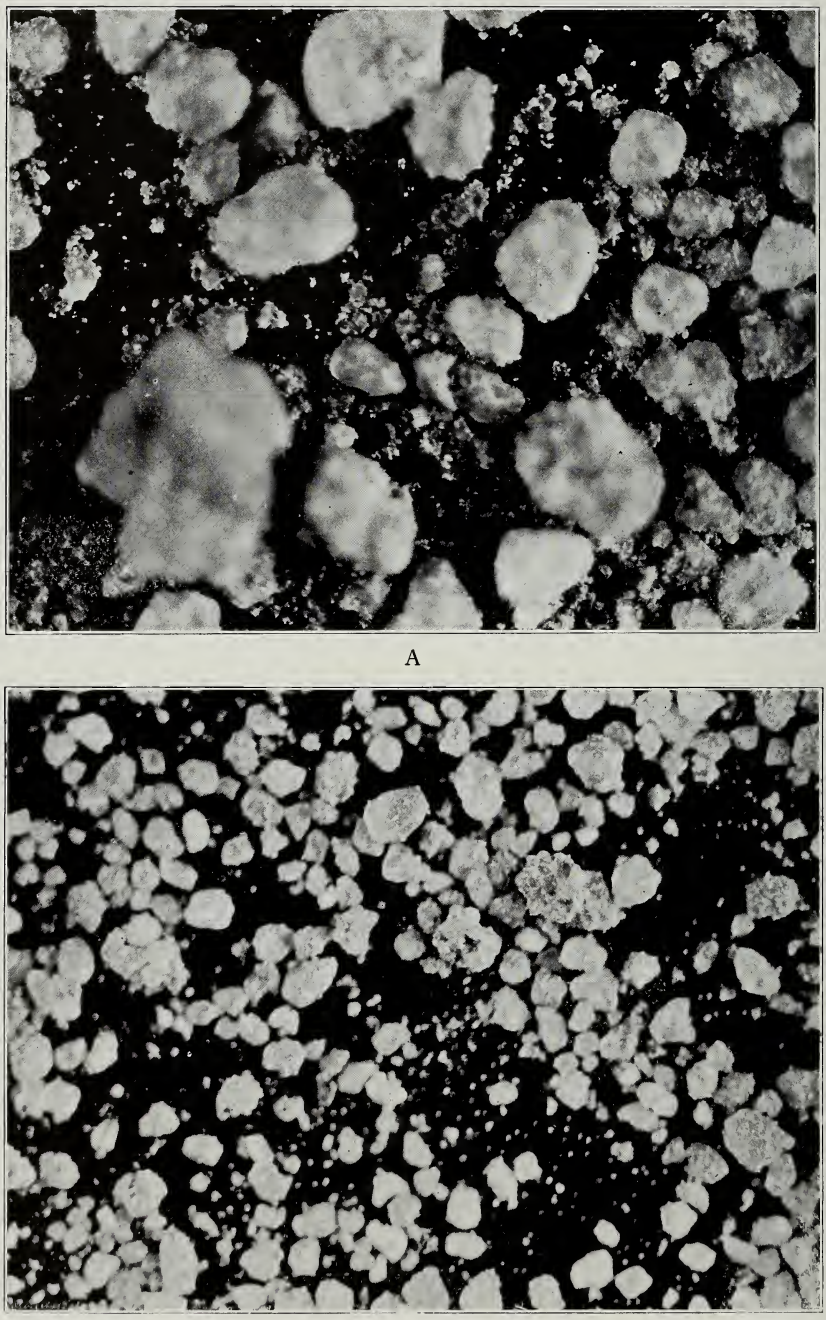
A

B

FIG. 29.—Microphotographs of Type I sand (x24). (See fig. 28 for fineness graphs.)

A. Undeveloped deposit, 5 miles south of Oregon, Ogle County. An exceptionally well sorted sand with hign percentage of clay. (Sample No. 57.)

B. G. Nicol and Son, Tamalco, Bond County. Sand grains less uniform in size than A, but the deposit has less silt. (Sample No. 166.)



A

B

FIG. 30.—Microphotographs of Type I sand (x24). (See fig. 28 for fineness graphs.)

A. Ed. B. Squier Co., Greenville, Bond County. A very coarse, well sorted sand. (Sample No. 171.)

B. Undeveloped deposit 1½ miles east of Carmi, White County. A well sorted sand, having a low silt percentage. (Sample No. 192.)

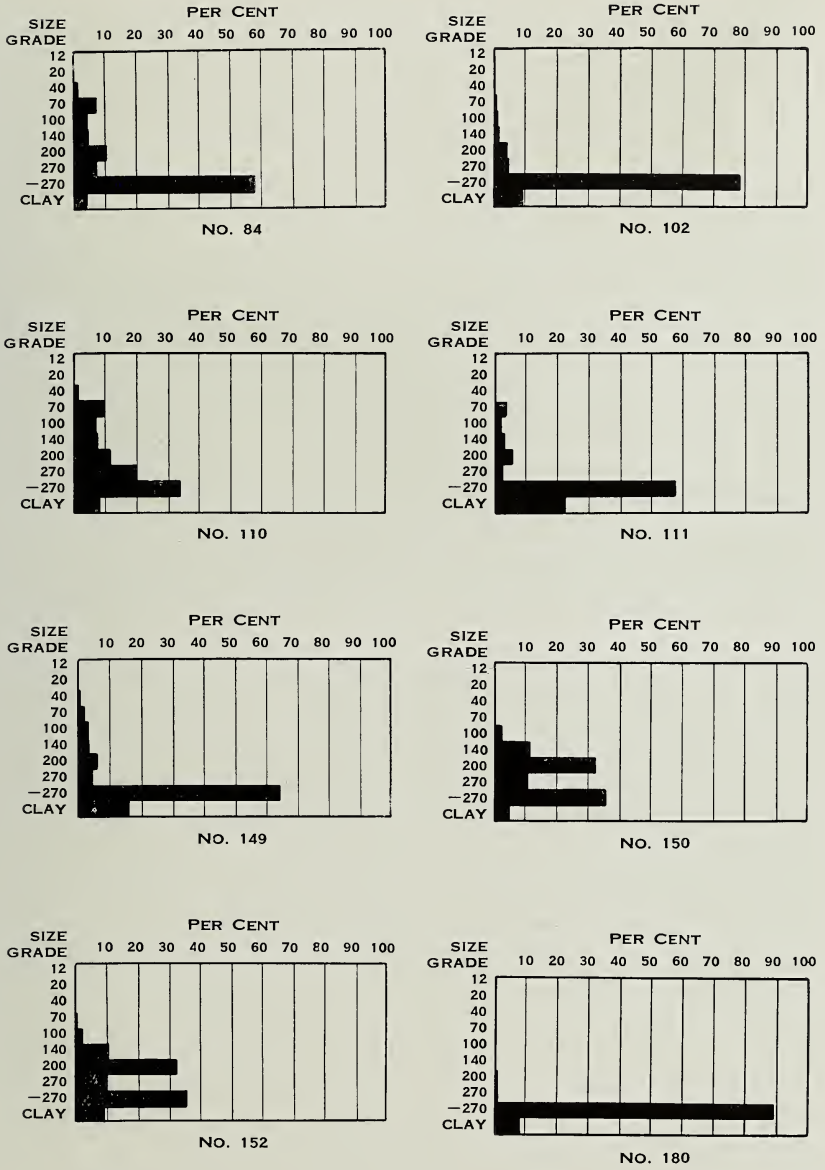
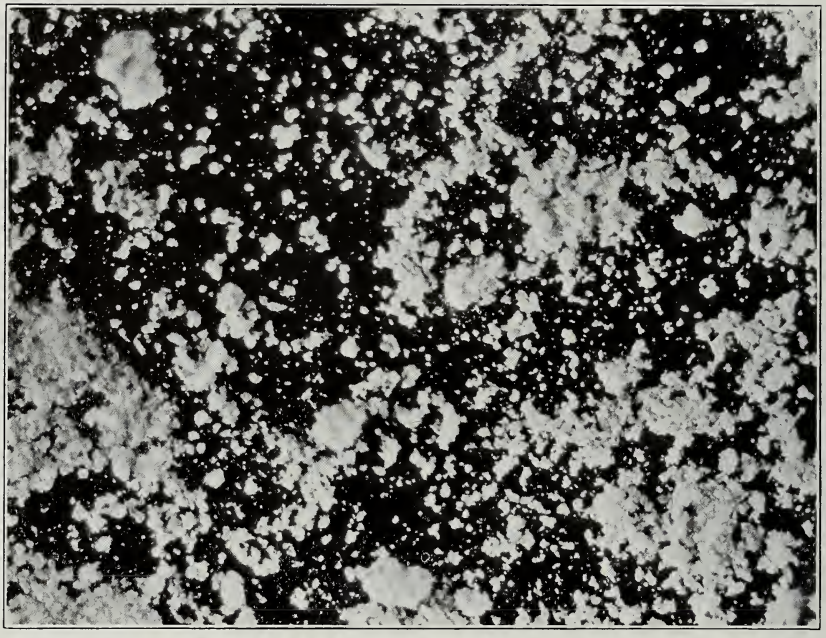



FIG. 31.—Fineness graphs of Type II molding sands. (See figs. 32 and 33.)

*Sample No. 84.* T. B. and S. S. Davis, Sears, Rock Island County. Collected at John Deere Harvester Works, East Moline.
*Sample No. 102.* T. B. and S. S. Davis, Sears, Rock Island County. Collected at Frank Foundries, Moline.
*Sample No. 110.* Undeveloped deposit, 1¼ miles west of Milan, Rock Island County.
*Sample No. 111.* Undeveloped deposit, 3 miles east of Green River Station, Henry County.
*Sample No. 149.* Purity Molding Sand Co., Dallas City, pit in Hancock County. Collected from Brass Foundry Co., Peoria.
*Sample Nos. 150 and 152.* Undeveloped deposit, 2½ miles east of Edwards, Peoria County.
*Sample No. 180.* O. J. Long, Caseyville, St. Clair County.



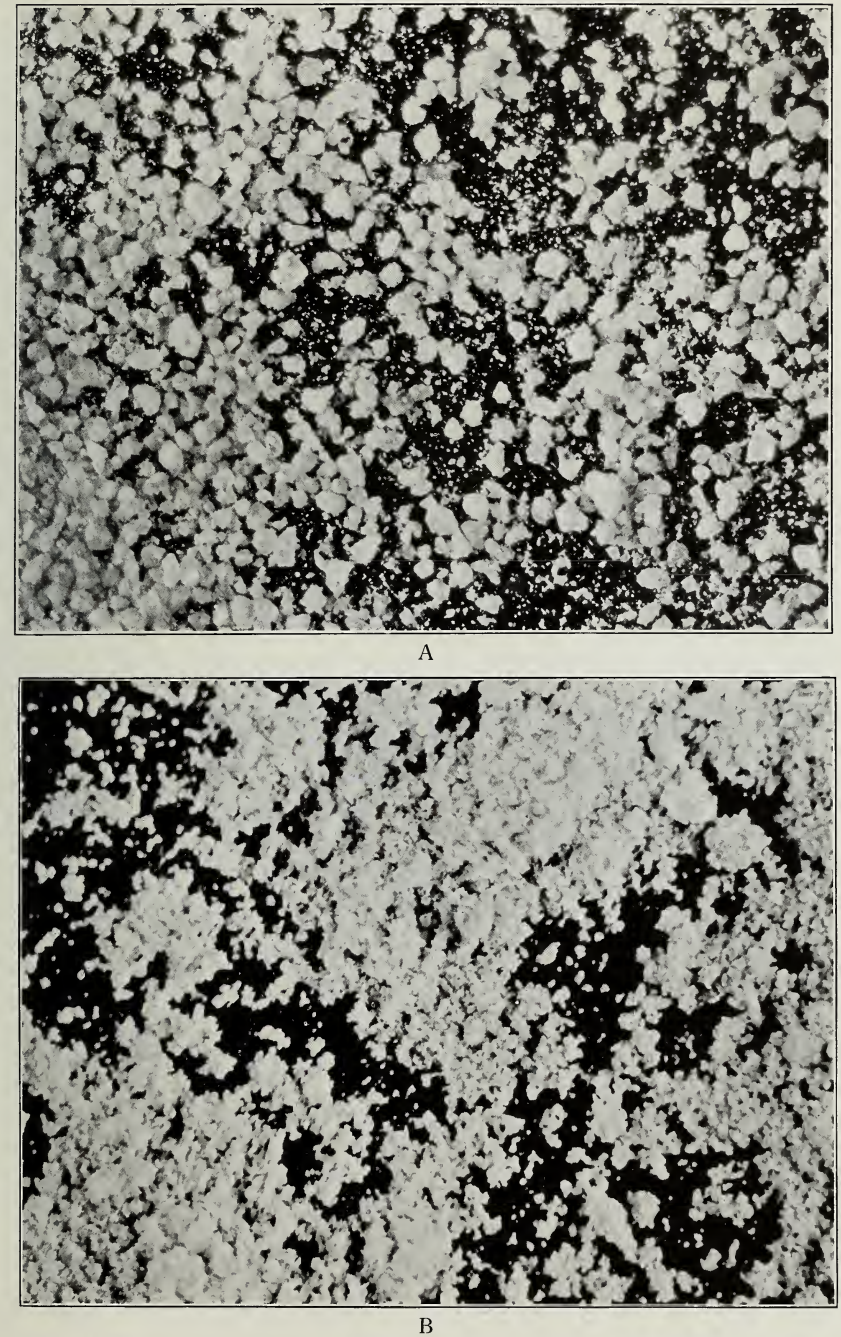
A

B

FIG. 32.—Microphotographs of Type II molding sands (x16). (See fig. 31 for fineness graphs.)

A. T. B. and S. S. Davis, Sears, Rock Island County. This is a loess. The apparent large grains are aggregates of silt grains. (Sample No. 102.)

B. Undeveloped deposit, 1¼ miles west of Milan, Rock Island County. Photograph is of rammed mold surface. (Sample No. 110.)



A

B

FIG. 33.—Microphotographs of Type II molding sands (x16). (See fig. 31 for fineness graphs.)

A. Undeveloped deposit, 2½ miles east of Edwards, Peoria County. A coarse Type II sand. (Sample No. 150.)

B. O. J. Long, Caseyville, St. Clair County. A loess. (Sample No. 180.)

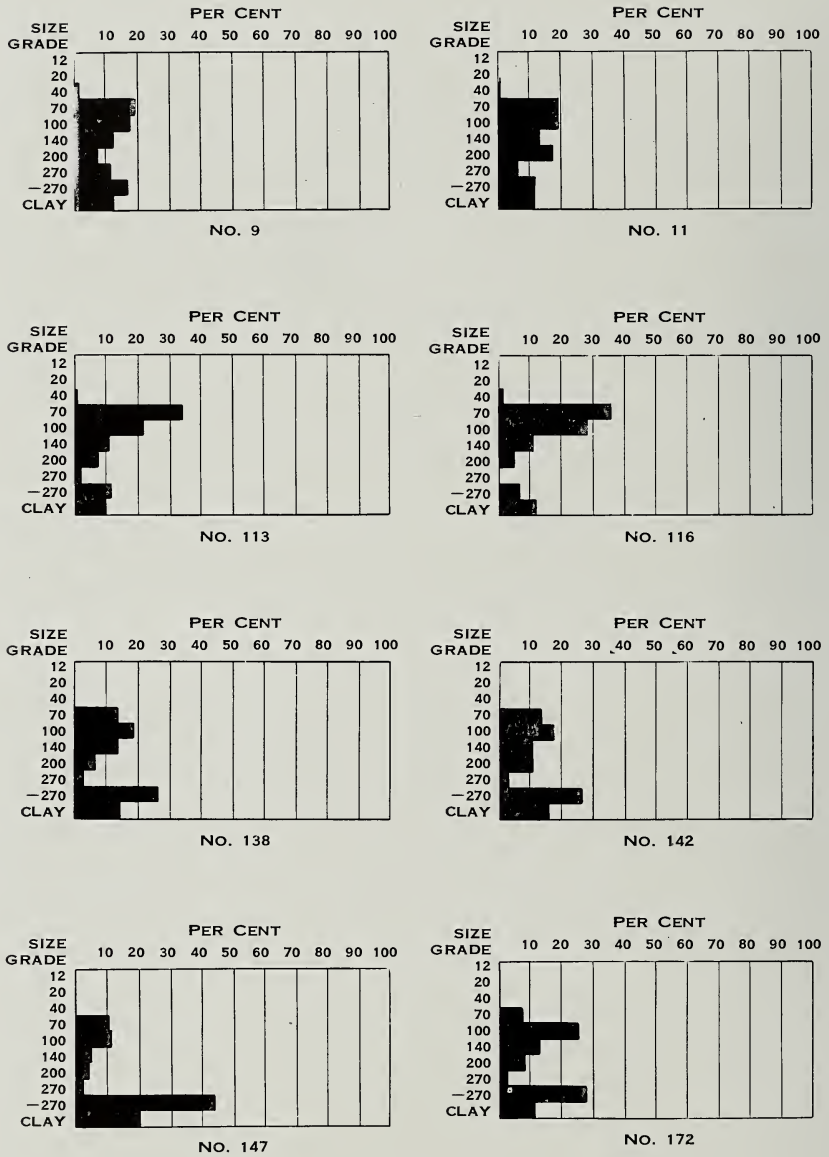
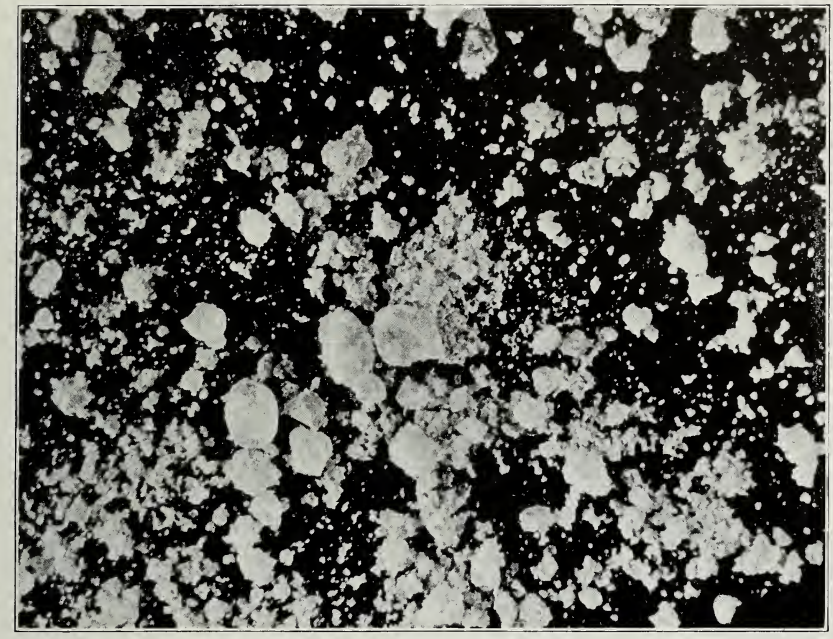
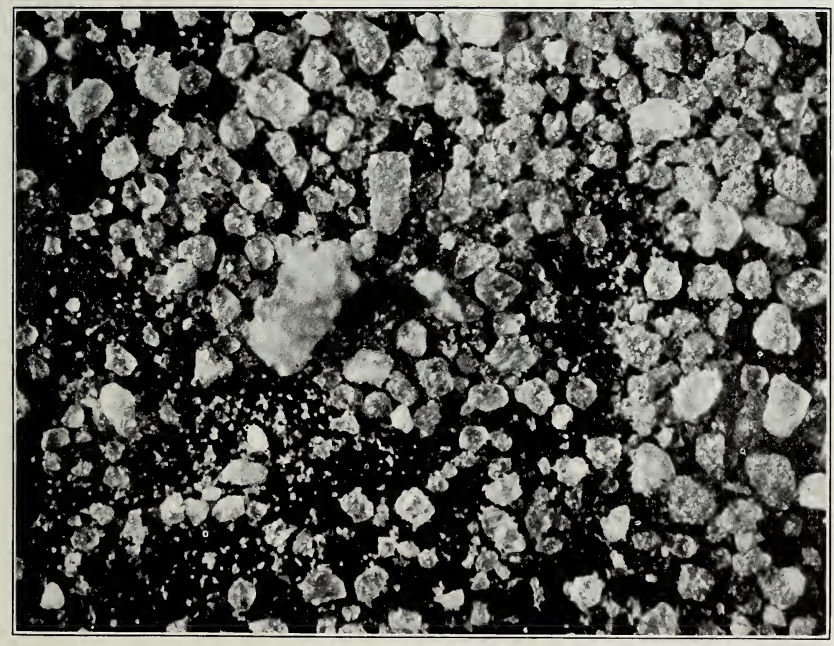



FIG. 34.—Fineness graphs of Type III molding sands. (See figs. 35 and 36.)

*Sample No. 9.* Garden City Sand Co., Algonquin, McHenry County. Type III*b*.
*Sample No. 11.* Larson and Larson, Ritchey, Will County. Type III*b*.
*Sample No. 113.* Golden and Larson, Wyanet, Bureau County. Type III*b*.
*Sample No. 116.* Jesse Westervilt, Buda, Bureau County. Type III*a*.
*Sample No. 138.* G. Nicol and Son, Arenzville, Cass County. Sample from Electric Wheel Co., Quincy. Type III*b*.
*Sample No. 142.* Monmouth Stone Co., Gladstone, Henderson County. From Gem City Stove Co., Quincy. Type III*b*.
*Sample No. 147.* Undeveloped deposit. Bluff Springs, Cass County. Type III*b*.
*Sample No. 172.* Commercial Foundry Sand Co., Collinsville, Madison County. Type III*b*.



A

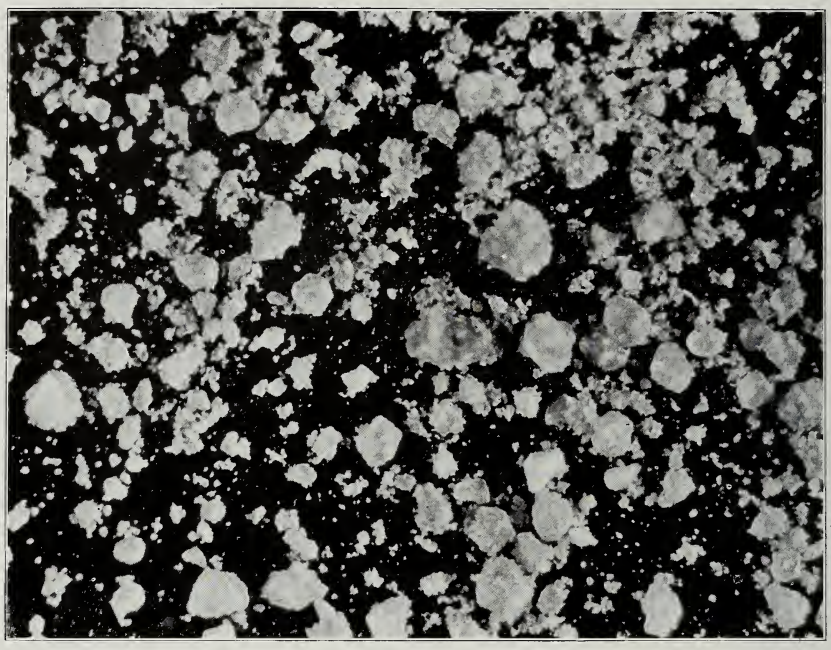


B

FIG. 35.—Microphotographs of Type III sands (x16). (See fig. 34 for fineness graphs.)

A. Garden City Sand Co., Algonquin, McHenry County. A poorly sorted sand; all size grades below 20-mesh are present. Type III*b*. (Sample No. 9.)

B. Jesse Westervilt, Buda, Bureau County. A well sorted sand. Except for its silt content, would be a Type I sand. Type III*a*. (Sample No. 116.)



A

B

FIG. 36.—Microphotographs of Type III sands (x16). See fig. 34 for fineness graphs.)

A. Monmouth Stone Co., Gladstone, Henderson County, Collected from Gem City Stove Co., Quincy. Poorly sorted and with relatively high silt content. Type III*b*. (Sample No. 142.)

B. Undeveloped deposit, Bluff Springs, Cass County. Poorly sorted and with excessively high silt content. Of small value as a commercial molding sand. (Sample No. 147.)

### TYPE II

Natural-bonded molding sands classified as Type II are those with maximum size grade percentage, excepting the silt (—270-mesh) and clay grades, on 140-mesh or below; with color reddish-yellow to buff; and with the quartz grains rarely coated with limonite. Black or "vegetable"-bond sand also falls into this type.

Type II includes all of the "fine" sands used for light-gray iron and non-ferrous work, for which high bond strength and permeability are not essential. Molds must faithfully reproduce intricate patterns and the sand must be so fine in texture that the resulting casting surface is smooth. A high degree of bond strength is not essential, although the mold must resist washing by the molten metal. High permeability is unnecessary, as a low permeability will give vent to the small volume of gas which results from small castings. It is desirable that the bond strength be uniform over a wide moisture range, for the mold can best be made with sand of high moisture content, but if the mold can dry so that the moisture content near the mold surface is low, the amount of steam incident to pouring is less, and less permeability is required. Type II sands containing amorphous clay usually have a wide range of bond strength from 4 per cent to 8 per cent moisture content. The permeability range is correspondingly great. The casting surface is less smooth, as the clay forms pellets. Figures 31, 32, and 33 illustrate Type II sands.

### TYPE III

Natural-bonded molding sands classified as Type III are those with maximum size grade percentage, excepting the silt ( $-270$) and clay grades, on or above 100-mesh; with a silt ( $-270$-mesh) percentage more than half the clay percentage; with color red to reddish-yellow. The quartz grains may or may not be coated with limonite.

Type III sands are to be regarded as the sands median in fineness, bond strength, and permeability, between Type I and Type II sands. They may be divided into two groups, Type III*a* and Type III*b*. Type III*a* represents those sands more akin to Type I than to Type II. Type III*b* sands are more nearly like Type II.

Type III*a* sands may be defined as those Type III sands which have a silt-to-clay ratio ranging from $\frac{1}{2}$ to 1. They are very commonly sands derived from deposits capable of yielding Type I molding sand, but with which considerable silt is included, either through difficulties of production or through carelessness. In other cases, the deposit is silty. These sands differ from Type I sands only in having a higher silt-clay ratio. Their bond strengths average lower and their average permeabilities are less than half the average for Type I sands.

Type III*b* sands may be defined as those Type III sands which have a silt-to-clay ratio greater than 1. They are the products of rather variable deposits. They are, in effect, mixtures of varying proportions of Type I and Type II sands. The average bond strength is no higher and the average permeabilities are almost as low as those of Type II sands (see Table I).

Type III sands are widely used as molding sands, not because they are best but because they are commonly available. Many deposits from which could be produced a single type, Type I or Type II, are producing a Type III sand. If plant-control methods of handling molding sand improve in the future as rapidly as in the past five years, many Type III sands will be forced off the market and will no longer be considered as molding sands. There are, however, some Type III sands which may serve special purposes much better than another sand. The better Type III sands, those which approximate either Type I or Type II, will serve quite as well as the true type in many cases, particularly in localities where only Type III sands can be obtained.

Figures 34, 35, and 36 illustrate Type III sands.

## Characteristic Type Relations

### Relation of optimum water content to type

The percentage of water at which the maximum bond strength and permeability of the samples are developed is shown in Table 18. It is to be understood that the optimum at 4 per cent may mean that the optimum is at 3 per cent or 2 per cent, and that the optimum at 8 per cent may mean that it really falls at a higher percentage.

Table 18.—*Position of Optimum Water Content by Types.*

| Type of molding sand | Total Number of samples | Number of samples | | | | | |
|---|---|---|---|---|---|---|---|
| | | Bond strength | | | Permeability | | |
| | | Per cent water | | | | | |
| | | 4 | 6 | 8 | 4 | 6 | 8 |
| I | 35 | 20 | 13 | 2 | 25 | 8 | 2 |
| II | 35 | 9 | 15 | 11 | 12 | 12 | 11 |
| III*a* | 19 | 8 | 6 | 5 | 11 | 6 | 2 |
| III*b* | 27 | 17 | 7 | 3 | 11 | 12 | 4 |

A given type of sand does not have a constant optimum but each type does have discernible tendencies.

1. Type I sands tend to develop maximum bond strength and permeability below 6 per cent water content. The increase of bond strength and permeability with increase of water content is gradual but the decrease with further increase in water content is rapid.

2. Type II sands tend to develop maximum bond strength at or above 6 per cent water content. Maximum permeability is developed at 6 per cent water content, but the quantitative range is so small that the permeability is nearly uniform through the 4 per cent to 8 per cent range.

3. Type III sands are so variable in properties that no very definite tendencies can be pointed out. Uniformity of bond strength throughout

the 4 per cent to 8 per cent range is common, but is far from the rule. Variations in methods of production, mulling, use, etc., probably change the position of the maximum bond strength with Type III sands, whereas it is doubtful if the position of the maximum bond strength of Types I and II could be changed by such procedure. The permeability of Type III*a* sands reaches a maximum between 4 per cent and 6 per cent. The permeability is similar to that of the Type I sands except that it is reduced to less than one half. The permeability of Type III*b* sands is similar to that of the Type II sands except that it is commonly greater.

## RELATION OF ORIGIN TO TYPE

It has been pointed out that the manner of deposition and the degree of weathering determine the fineness of a molding sand and that deposits of similar origin may be expected to produce molding sands of similar properties. Table 19 gives the averages of fineness of Illinois molding sands grouped by origin. The fluvio-glacial, terrace-dune, and upland-dune sands are Type I, the stream-terrace, alluvial, and loess sands, Type II, and the slope-mantle sands, Type III*b*. Type III*a* is not represented, for, as has been mentioned, such sands are commonly produced from deposits of Type I sand.

When the averages of bond strength and permeability of all Type I sands (Table 17) are compared with those of the three origin-groups which have Type I fineness (Table 21), it is seen that there is a marked similarity.

TABLE 19.—*Average fineness of groups of natural-bonded molding sands of similar origin.*

| Kind of Deposit | Number of Samples | Size grade | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12 | 20 | 40 | 70 | 100 | 140 | 200 | 270 | —270 | Clay | Total |
| Fluvio-glacial | 14 | .7 | 1.5 | 5.6 | 37.0 | 15.4 | 7.2 | 4.6 | 1.1 | 7.5 | 18.5 | 99.1 |
| Terrace dune | 17 | .2 | 1.3 | 5.4 | 30.3 | 16.2 | 11.3 | 9.5 | 1.9 | 6.2 | 16.7 | 99.0 |
| Upland dune | 13 | .. | .3 | 1.6 | 30.8 | 21.5 | 10.7 | 7.8 | 2.0 | 7.4 | 17.1 | 99.2 |
| Slope mantle | 36 | .. | ... | .5 | 15.4 | 15.9 | 10.5 | 10.6 | 3.9 | 26.3 | 16.2 | 99.3 |
| Stream terrace | 22 | .. | .1 | 1.2 | 12.5 | 10.9 | 10.0 | 13.5 | 6.4 | 25.9 | 18.9 | 99.4 |
| Alluvium | 4 | .. | ... | .6 | 4.4 | 11.6 | 19.7 | 20.3 | 6.0 | 23.1 | 13.5 | 99.2 |
| Loess | 10 | .. | ... | .2 | 3.8 | 4.4 | 3.8 | 6.9 | 4.8 | 65.3 | 10.2 | 99.4 |

TABLE 20.—*Average bond strength and permeability of natural-bonded molding sands grouped by origin.*

| Kind of Deposit | Number of Samples | Bond Strength | | | Permeability | | | Base Permeability |
|---|---|---|---|---|---|---|---|---|
| | | Per cent Water | | | Per cent Water | | | |
| | | 4 | 6 | 8 | 4 | 6 | 8 | |
| Fluvio-glacial | 14 | 317.6 | 324.5 | 279.7 | 116.7 | 87.8 | 66.2 | 100.8 |
| Terrace dunes | 17 | 264.8 | 255.6 | 221.3 | 92.6 | 73.0 | 54.2 | 80.2 |
| Upland dunes | 13 | 266.4 | 258.1 | 231.3 | 73.2 | 66.3 | 47.0 | 61.8 |
| Slope mantle | 36 | 229.3 | 226.1 | 213.8 | 20.3 | 20.3 | 17.4 | 18.0 |
| Stream terrace | 22 | 204.2 | 218.3 | 217.6 | 20.0 | 21.7 | 19.3 | 21.5 |
| Alluvium | 4 | 214.4 | 218.3 | 212.7 | 15.7 | 14.2 | 13.1 | 16.3 |
| Loess | 10 | 199.1 | 204.5 | 194.9 | 6.1 | 6.3 | 6.3 | 8.1 |

TABLE 21.—*Comparison of average bond strength and permeability of all Type I sands with similar averages for the three origin-groups having Type I fineness.*

| Kind of sand | No. of samples | Bond strength | | | Permeability | | | Base permeability |
|---|---|---|---|---|---|---|---|---|
| | | Per cent water | | | | | | |
| | | 4 | 6 | 8 | 4 | 6 | 8 | |
| Type I | 35 | 290.2 | 282.9 | 255.4 | 103.5 | 84.9 | 59.8 | 90.2 |
| Fluvio-glacial<br>Terrace dune<br>Upland dune | 44 | 282.9 | 279.4 | 244.0 | 94.2 | 75.4 | 55.8 | 80.9 |

The similarity is again marked when Type II (Table 17) averages are compared with the averages of those groups whose average fineness falls within Type II (Table 22).

TABLE 22.—*Comparison of average bond strength and permeability of all Type II sands with similar averages for the three origin-groups having Type II fineness.*

| Kind of sand | No. of samples | Bond strength | | | Permeability | | | Base permeability |
|---|---|---|---|---|---|---|---|---|
| | | Per cent water | | | | | | |
| | | 4 | 6 | 8 | 4 | 6 | 8 | |
| Type II | 35 | 208.3 | 219.2 | 212.6 | 12.4 | 12.9 | 12.1 | 13.2 |
| Stream terrace<br>Alluvium<br>Loess | 34 | 205.9 | 213.4 | 208.4 | 13.9 | 14.1 | 12.9 | 15.3 |

Comparison of Type III*b* averages (Table 17) with those of the slope-mantle group (Table 23) also shows similarity.

TABLE 23.—*Comparison of average bond strength and permeability of all Type III*b *sands with similar averages for the origin group having Type III*b *fineness.*

| Kind of sand | No. of samples | Bond strength | | | Permeability | | | Base permeability |
|---|---|---|---|---|---|---|---|---|
| | | Per cent water | | | | | | |
| | | 4 | 6 | 8 | 4 | 6 | 8 | |
| Type III*b* | 37 | 220.1 | 219.7 | 201.7 | 18.1 | 19.0 | 16.1 | 15.1 |
| Slope mantle | 36 | 229.3 | 226.1 | 213.8 | 20.3 | 20.3 | 16.4 | 18.0 |

Clearly, molding sands, when grouped by origin, show inter-group differences in the averages of fineness, bond strength, and permeability. However, the mean of the averages of bond strength and permeability of the origin groups which fall within the same type conforms with the averages of bond strength and permeability of that type.

### CONFORMITY OF ORIGIN AND TYPE

The number of samples in each origin-group which fall into the various types (Table 24) is significant. Of the fluvio-glacial, terrace-dune, and upland-dune groups, forty-four samples in all, thirty-two are Type I, nine are Type III*a*, one is Type III*b*, and two are Type II. The ten Type III sands are cases in which silt was included during production and Type I sands could be produced from their respective deposits. The two Type II sands of the terrace-dune group are normal for the deposits from which they were produced, but such deposits are very rare. Molding sand occurring in fluvio-glacial ridges, dunes on stream terraces, and dunes on uplands, will normally be Type I molding sand, but the methods of production may introduce sufficient silt to make them Type III. Type II sand is rarely found in these deposits. Furthermore, such deposits are relatively uniform in fineness throughout, the clay grade excepted. For that reason, continued production from these deposits will be uniform as to permeability but may vary in bond strength.

Windblown slope-mantle deposits are represented in all types. Twenty-six out of thirty-six are of Type III, eight of Type II, and two of Type I.

TABLE 24.—*Distribution of sands of similar origin among the types.*

| Kind of deposit | Number of samples | Type of molding sand | | | |
|---|---|---|---|---|---|
| | | I | II | III*a* | III*b* |
| Fluvio-glacial | 14 | 12 | .. | 2 | .. |
| Terrace dunes | 17 | 12 | 2 | 3 | .. |
| Upland dunes | 13 | 8 | .. | 4 | 1 |
| Slope mantle | 36 | 2 | 8 | 5 | 21 |
| Stream terrace | 22 | 1 | 12 | 5 | 4 |
| Alluvium | 4 | .. | 4 | .. | .. |
| Loess | 10 | .. | 9 | .. | 1 |

Type I sands are so rare in slope-mantle deposits that it is not probable Type I sands could be produced in any quantity. The normal expectation from slope-mantle deposits is Type III*b*, for Type II and Type III*a* sands are derived only from a small part of the deposit. They may be regarded as "forced" production from selected areas rather than as normal pit run which could be maintained until the deposit was worked out.

Stream-terrace and alluvial deposits normally yield Type II sands. It is probable that any Illinois stream which has a flood plain more than a quarter of a mile wide is depositing Type II material, but not all of that material is suitable for use as molding sand. Molding sand pits in stream-

TABLE 25.—*Relation of clay percentages to average natural permeability by types.*

| Clay percentage | Type I | | | Type II | | | Type III*a* | | | Type III*b* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Average natural permeability | | | | | | | | | | | |
| | Water per cent | | | | | | | | | | | |
| | 4 | 6 | 8 | 4 | 6 | 8 | 4 | 6 | 8 | 4 | 6 | 8 |
| 5– 9.9 | ..... | .... | .... | 10.1 | 9.8 | 10.4 | .... | .... | .... | 16.4 | 16.4 | 14.8 |
| 10–14.9 | 109.3 | 93.4 | 62.9 | 16.5 | 15.1 | 14.2 | 56.3 | 43.4 | 33.7 | 22.0 | 21.2 | 17.4 |
| 15–19.9 | 113.9 | 84.4 | 63.4 | 15.3 | 15.2 | 14.1 | 45.9 | 42.7 | 34.5 | 17.9 | 17.6 | 16.1 |
| 20–24.9 | 100.7 | 82.3 | 58.3 | 10.8 | 10.9 | 8.1 | .... | 27.2 | 26.0 | 12.6 | 17.1 | 13.7 |
| 25–29.9 | 75 8 | 79.0 | 53.8 | 10.9 | 12.6 | 12.4 | .... | .... | .... | .... | .... | .... |

terrace deposits are commonly in the coarsest phases found, which accounts for the Type I and Type III sands. The single Type I sand is a notable exception, but the Type III sands are not exceptional. The molding sands which are derived from loess deposits are, with one exception, of Type II. Only Type II sands can be normally expected from loess.

### RELATION OF CLAY CONTENT TO NATURAL PERMEABILITY BY TYPES

The relation of the clay content to natural permeability, Table 25, the size-grade distribution being constant, is quantitatively negligible. Each group represented by averages in Table 25 is composed of three or more samples. Those samples containing between 10 per cent and 20 per cent clay show the maximum permeability in each type.

### RELATION OF SILT CONTENT TO NATURAL AND BASE PERMEABILITY BY TYPES

The permeabilities decrease with increase in silt percentage in all types (Table 26). The rate of decrease of permeability varies with the type of sand, but in general it is progressively less with a constant rate of increase of silt percentage. Thus, starting with a Type I sand, the addition of enough silt to raise its silt percentage to approximately 9 per cent would reduce its permeability almost half. A further addition of silt would probably make it a Type III*a* sand, with a loss of one third in permeability. Further additions of silt would decrease the permeability but little because of the fact that the interstices between the grains would be filled, that is, a point of saturation would be reached beyond which the permeability would decrease very little.

### RELATION OF BASE TO NATURAL PERMEABILITY BY TYPES

1. The base-permeability values (Table 27) of most Type I sands lie between the maximum and minimum of natural-permeability values for the 4 per cent to 8 per cent water-content range, for the reason that the maximum and minimum natural-permeability values are far apart in this type of sand.

2. The base-permeability values of most of the Type II sands fall within the natural permeability range or at the maximum. The large proportion falling at the maximum is due to the relatively low natural-permeability values of this type, which made the tolerance limit of 1½, as stated in the table heading, much greater than in the case of Type I sands.

3. Type III sands show a greater variation, with a marked tendency for the base-permeability values to be lower than the minimum natural-permeability value.

4. The averages of all types are significant in that they show that approximately half the total number of Illinois molding sands have a base-permeability value between the minimum and maximum values, or at the maximum value of the natural permeability in the 4 per cent to 8 per cent water-content range; and that the other half are distributed evenly, one

TABLE 26.—*Relation of silt percentage to average natural and base permeabilities by types*

| Silt percentage | Type I | | | | Type II | | | | Type III*a* | | | | Type III*b* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water per cent | | | Base permeability | Water per cent | | | Base permeability | Water per cent | | | Base permeability | Water per cent | | | Base permeability |
| | 4 | 6 | 8 | | 4 | 6 | 8 | | 4 | 6 | 8 | | 4 | 6 | 8 | |
| 0– 4.9 | 137.9 | 110.3 | 74.0 | 108.8 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 5– 9.9 | 70.1 | 53.2 | 48.9 | 68.9 | 36.7 | 37.2 | 34.3 | 33.1 | 56.3 | 43.4 | 34.0 | 42.1 | ..... | ..... | ..... | ..... |
| 10–14.9 | ..... | ..... | ..... | ..... | | | | | 49.0 | 41.0 | 35.5 | 40.7 | 32.3 | 31.3 | 24.7 | 23.6 |
| 15–19.9 | ..... | ..... | ..... | ..... | 21.6 | 21.1 | 19.7 | 20.6 | ..... | 24.9 | 23.5 | 19.2 | 24.4 | 23.6 | 20.9 | 14.4 |
| 20–24.9 | ..... | ..... | ..... | ..... | 15.9 | 15.5 | 14.0 | 15.6 | | | | | 10.9 | 16.9 | 15.1 | 14.6 |
| 25–29.9 | ..... | ..... | ..... | ..... | 13.0 | 13.1 | 12.1 | 14.6 | ..... | ..... | ..... | ..... | 18.3 | 18.1 | 15.6 | 14.9 |
| 30–34.9 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 13.7 | 13.7 | 12.4 | 13.7 |
| 35–39.9 | ..... | ..... | ..... | ..... | 10.9 | 10.1 | 10.6 | 11.9 | ..... | ..... | ..... | ..... | | | | |
| 40–44.9 | | | | | | | | | | | | | | | | |
| 45–49.9 | | | | | | | | | | | | | 5.6 | 7.6 | 7.1 | 8.9 |
| 50–54.9 | | | | | | | | | | | | | | | | |
| 55–59.9 | ..... | ..... | ..... | ..... | 8.0 | 7.9 | 7.1 | 9.7 | ..... | ..... | ..... | ..... | | | | |
| 60–64.9 | | | | | | | | | | | | | | | | |
| 65–69.9 | | | | | | | | | | | | | | | | |
| 70–74.9 | | | | | | | | | | | | | | | | |
| 75–79.9 | ..... | ..... | ..... | ..... | 4.9 | 5.1 | 4.7 | 6.7 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

TABLE 27.—*Relation of base permeability to natural permeability within the 4 per cent to 8 per cent water-content range, by types.*

| Type of Molding sand | Number of samples | Base permeability value below the minimum value of the natural permeability | Base permeability value between the maximum and minimum values of the natural permeability | Base permeability value coincident with maximum value of natural permeability | Base permeability value above maximum value of the natural permeability |
|---|---|---|---|---|---|
| Type I | 35 | 20.0 | 48.6 | 2.8 | 28.6 |
| Type II | 35 | 8.6 | 22.9 | 37.1 | 31.4 |
| Type III*a* | 19 | 31.6 | 26.3 | 10.5 | 31.6 |
| Type III*b* | 27 | 48.2 | 22.2 | 14.8 | 14.8 |
| Average of all types | 116 | 27.1 | 30.0 | 16.3 | 26.6 |

fourth above the maximum, and one fourth below the minimum natural-permeability value.

## RELATION OF DURABILITY TO TYPES

The average percentage of loss of bond strength for Type I sands (Table 28) is high, probably because these sands have clay grades which are almost entirely amorphous clay. With the data available, no direct quantitative relation is apparent between clay percentage and durability, yet it seems certain that such a relation must exist. For example, a sand with a very high clay content tends to have maximum bond strength at 6 per cent, 8 per cent, or 10 per cent water content. The reduction of clay content by the partial dehydration of the clay probably lowers the optimum water percentage, and may or may not reduce bond strength, depending upon the relation of bond strength to clay content. In Type I sands, maximum bond strength increases with increase in clay content, the water content being constant, and a reduction of the clay content by partial dehydration serves to reduce bond strength. The percentage of bond strength lost by sands of Types II and III are probably more nearly actual losses in available bond strength because of the fact of more bond strength throughout the moisture range. However, until the relative importance of the factors of reduction of clay content, migration of optimum water content, and quality of clay, are established, the behavior of sand under use cannot be predicted.

TABLE 28.—*Durability of molding sands by types.*

| Type of molding sand | Number of samples | Bond strength loss | | |
|---|---|---|---|---|
| | | Maximum | Minimum | Average |
| | | Per cent | Per cent | Per cent |
| Type I..... | 7 | 37.7 | 5.1 | 26.4 |
| Type II..... | 13 | 31.2 | Gain 2.0 | 12.9 |
| Type III*a*..... | 8 | 19.8 | 4.1 | 11.4 |
| Type III*b*..... | 10 | 32.6 | Gain 4.3 | 15.2 |
| All types..... | 38 | 37.7 | Gain 4.3 | 15.7 |

## Importance and Use of Type Classification of Natural-Bonded Molding Sands

A detailed classification of molding sands would be so complex as to be undesirable. However, some logical scheme of basal division is needed by which the general character of a sand may be stated. The use of qualitative terms, such as fine, coarse, open, and heavy, in any but a comparative sense, cannot be recommended. They are colloquial rather than technical, for as descriptive terms they are only relative to the judgment of the man employing them.

It is hoped that the Type Classification of molding sands, given in this chapter, will be of value to both foundrymen and molding sand producer.

If the foundryman knows to a certainty the degrees of the various properties of the molding sand suited to his work, he may describe the desired sand in terms of the Type Classification given above. Only those producing deposits which normally produce that type need be considered as possibilities, and of them only the particular deposit capable of furnishing a uniform sand of the required bond strength, permeability, refractoriness, and durability. The greater the number of commercial grades produced from a single deposit the less is the likelihood of the uniformity of production of any. The relation of physical properties to origin is so definite that the long-continued production of several uniform commercial grades from a single deposit is impossible.

If the molding sand producer will describe his product according to the physical properties, he will be better able to serve the foundryman satisfactorily. Because of the fact that each deposit can produce only a limited range of fineness without resorting to mixing with its resultant loss of degree of physical properties, the foundryman must not bring his limits of tolerance of bond strength and permeability to such a narrow range that the producer cannot maintain a uniform grade.

# CHAPTER VI.—COUNTY REPORTS AND RESULTS OF TESTS

## Introduction

Those counties which contain possible or proved deposits of molding sand are treated as units in the following pages. The remaining counties are not favorable areas for extensive or valuable deposits of molding sand. However, many of these counties do contain deposits which might be utilized by local foundries and it is reasonable to suppose that they may contain some deposits which, due to exceptional geologic conditions, might be of value. A generalized mention of the areas in which certain types of sand may be found will serve as a statement of the resources of these counties. Table 29 indicates the occurrence by counties of various kinds of deposits and the Type Classification (see Chapter V, page 75) of their sands. Figure 37 shows graphically the production of the various types of natural-bonded molding sand by counties. In many of these counties lack of demand for molding sand makes potential deposits valueless. As has already been mentioned, the State's resources of alluvium and loess have not been included in the estimate of the quantity of available molding sand, for their small use in a few localities does not necessarily imply value. The number of producers working deposits are stated and in the last column the total number of producers is given. In some counties one producer works one or more deposits, hence the apparent error. Those deposits which were seen and sampled are indicated by P, that is, such a deposit, known to contain molding sand, is present. Deposits which are favorable, that is, the deposits present in which molding sand might be found, are indicated by F.

## Review of Kinds of Deposits[1]

### ALLUVIUM

Alluvial deposits on the flood plains of rivers are sometimes utilized as molding sand. In most cases alluvial deposits are so variable that the production of a uniform grade is impossible. The physical properties of such sands are rather distinct, and they may be classified as Type II. It is evident that this type of molding sand may be found along every stream which has a flat flood plain. In the case of large streams, such as the Mississippi and the Illinois, the alluvial material deposited adjacent to the bank is the coarsest. Along the smaller winding streams the upstream end of deposits lying within a curve of the channel tend to be coarsest. Those counties in which the stream flood plains do or may yield alluvium suitable for use as molding sand are indicated in Column 1 of Table 29.

### LOESS

The loess, or calcareous yellow silt, occurs in abundance in several counties. The demand for loess as molding sand is small and deposits

[1]For further information, see Chapters II, III and V.

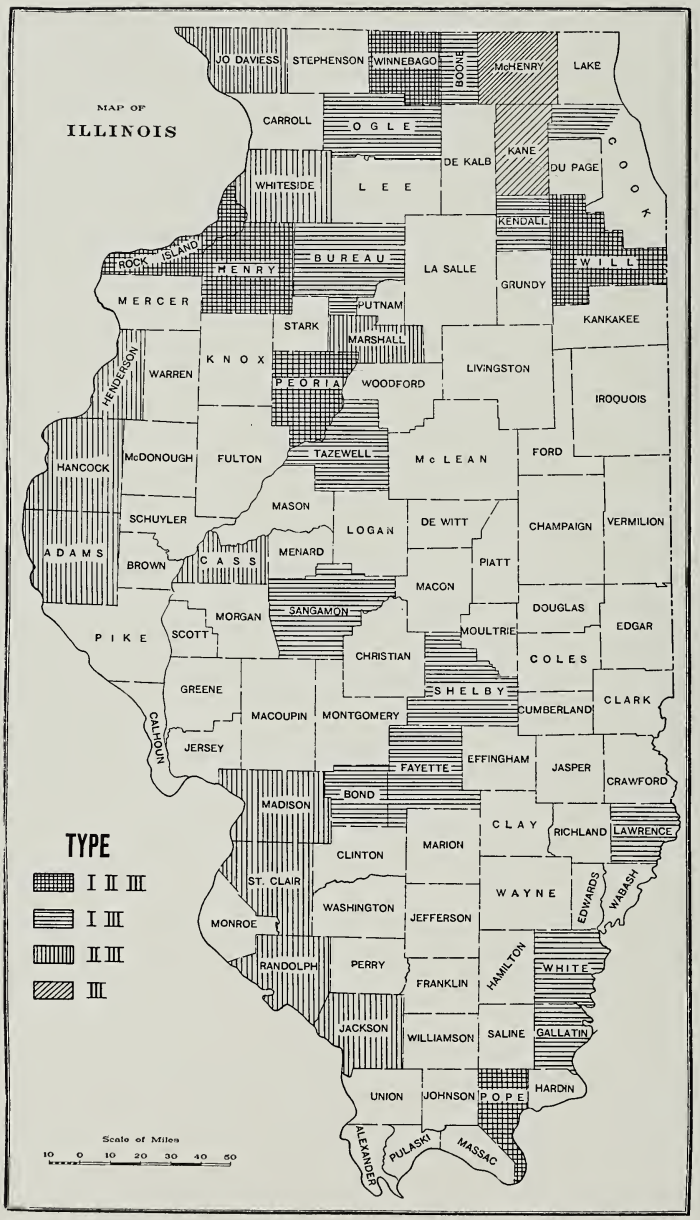



FIG. 37.—Outline map of Illinois showing the types of natural-bonded molding sand available.

TABLE 29. *Summary of the kind of deposit and the type of sand present and produced, by counties.*

| County | Type of molding sand | | | | | | | Number of producers |
|---|---|---|---|---|---|---|---|---|
| | Black, II | Calcareous yellow, II | Yellow to red, III | Red, I and III | Red I—III | Red III | I—III | |
| | Kind of deposit | | | | | | | |
| | Alluvial deposits | Loess | Windblown slope mantle | Old dunes on terraces | Old dunes on uplands | Stream terraces | Fluvio-glacial | |
| | Column 1 | Column 2 | Column 3 | Column 4 | Column 5 | Column 6 | Column 7 | |
| Adams | F | 2 | 1 | .. | .. | .. | .. | 2 |
| Alexander | F | .. | .. | .. | .. | .. | .. | .. |
| Bond | .. | .. | .. | .. | .. | .. | 5 | 5 |
| Boone | .. | .. | .. | .. | .. | P | .. | .. |
| Brown | F | F | .. | .. | .. | .. | .. | .. |
| Bureau | F | F | .. | .. | 3 | .. | .. | 3 |
| Calhoun | F | .. | .. | .. | .. | .. | .. | .. |
| Carroll | F | F | F | .. | .. | .. | .. | .. |
| Cass | F | F | 1 | .. | .. | .. | .. | 1 |
| Champaign | .. | .. | .. | .. | .. | .. | .. | .. |
| Christian | F | .. | .. | .. | .. | .. | F | .. |
| Clark | F | .. | .. | F | .. | F | .. | .. |
| Clay | F | .. | .. | .. | .. | .. | .. | .. |
| Clinton | F | .. | .. | .. | .. | .. | F | .. |
| Coles | .. | .. | .. | .. | .. | .. | .. | .. |
| Cook | .. | .. | .. | F | F | .. | .. | .. |
| Crawford | F | .. | .. | F | .. | F | .. | .. |
| Cumberland | .. | .. | .. | .. | .. | .. | .. | .. |
| De Kalb | F | .. | .. | .. | .. | F | .. | .. |
| De Witt | .. | .. | .. | .. | .. | .. | F | .. |
| Douglas | .. | .. | .. | .. | .. | .. | .. | .. |
| Du Page | F | .. | .. | .. | .. | .. | .. | .. |
| Edgar | .. | .. | .. | .. | .. | .. | .. | .. |
| Edwards | F | .. | .. | .. | .. | F | .. | .. |
| Effingham | .. | .. | .. | .. | .. | .. | .. | .. |
| Fayette | F | .. | .. | .. | 1 | .. | 4 | 4 |
| Ford | .. | .. | .. | .. | .. | .. | .. | .. |
| Franklin | F | .. | .. | .. | .. | .. | .. | .. |
| Fulton | F | .. | .. | .. | .. | .. | .. | .. |
| Gallatin | F | .. | P | F | .. | F | .. | .. |
| Greene | F | .. | .. | .. | .. | .. | .. | .. |
| Grundy | F | .. | .. | .. | .. | .. | P | .. |
| Hamilton | .. | .. | .. | .. | .. | .. | .. | .. |
| Hancock | F | 1 | 1 | .. | .. | .. | .. | 1 |
| Hardin | .. | .. | .. | .. | .. | .. | .. | .. |
| Henderson | F | 2 | 3 | P | .. | .. | .. | 5 |
| Henry | F | F | 1 | P | .. | P | .. | 1 |
| Iroquois | .. | .. | .. | .. | .. | F | .. | .. |
| Jackson | F | .. | .. | .. | .. | P | .. | .. |
| Jasper | F | .. | .. | .. | .. | .. | .. | .. |
| Jefferson | .. | .. | .. | .. | .. | .. | .. | .. |
| Jersey | F | .. | .. | .. | .. | .. | .. | .. |
| Jo Daviess | F | 1 | .. | .. | .. | 1 | .. | 1 |
| Johnson | F | .. | .. | .. | .. | .. | .. | .. |
| Kane | .. | .. | 3 | .. | 1 | 2 | .. | 5 |
| Kankakee | F | .. | .. | F | .. | F | .. | .. |
| Kendall | F | .. | P | .. | .. | .. | .. | .. |
| Knox | F | .. | .. | .. | .. | .. | .. | .. |
| Lake | F | .. | .. | F | F | .. | .. | .. |
| La Salle | F | .. | .. | .. | .. | P | .. | .. |
| Lawrence | F | .. | P | P | .. | F | .. | .. |
| Lee | F | .. | .. | .. | F | F | .. | .. |
| Livingston | .. | .. | .. | .. | .. | .. | .. | .. |
| Logan | F | .. | .. | .. | .. | .. | .. | .. |
| McDonough | F | .. | .. | .. | .. | .. | .. | .. |
| McHenry | F | .. | .. | .. | F | 1 | .. | 1 |
| McLean | .. | .. | .. | .. | .. | .. | .. | .. |
| Macon | F | .. | .. | .. | .. | .. | .. | .. |
| Macoupin | F | .. | .. | .. | .. | .. | .. | .. |
| Madison | F | P | 2 | .. | .. | F | .. | 2 |
| Marion | .. | .. | .. | .. | .. | .. | .. | .. |
| Marshall | F | .. | .. | .. | F | P | .. | .. |

F.—Favorable deposits present.
P.—Possible source; sampled.
5.—Number of producers of the kind of sand indicated.

TABLE 29. *Summary of the kind of deposit and the type of sand present and produced, by counties*—Continued.

| County | Type of molding sand | | | | | | | Number of producers |
|---|---|---|---|---|---|---|---|---|
| | Black, II | Calcareous yellow, II | Yellow to red, III | Red, I and III | Red I—III | Red III | I—III | |
| | Kind of deposit | | | | | | | |
| | Alluvial deposits | Loess | Windblown slope mantle | Old dunes on terraces | Old dunes on uplands | Stream terraces | Fluvio-glacial | |
| | Column 1 | Column 2 | Column 3 | Column 4 | Column 5 | Column 6 | Column 7 | |
| Mason | F | .. | .. | .. | F | .. | .. | .. |
| Massec | F | .. | .. | .. | .. | .. | .. | .. |
| Menard | F | .. | .. | .. | F | .. | .. | .. |
| Mercer | F | F | F | .. | .. | .. | .. | .. |
| Monroe | F | F | .. | .. | .. | .. | .. | .. |
| Montgomery | .. | .. | .. | .. | .. | .. | F | .. |
| Morgan | .. | .. | .. | .. | .. | .. | .. | .. |
| Moultrie | .. | .. | .. | .. | .. | .. | .. | .. |
| Ogle | F | .. | P | .. | F | P | .. | .. |
| Peoria | F | .. | .. | 1 | .. | P | .. | 1 |
| Perry | F | .. | .. | .. | .. | .. | .. | .. |
| Piatt | .. | .. | .. | .. | .. | .. | .. | .. |
| Pike | F | F | .. | .. | .. | .. | .. | .. |
| Pope | P | .. | .. | P | .. | P | .. | .. |
| Pulaski | F | .. | .. | .. | .. | .. | .. | .. |
| Putnam | F | .. | F | .. | F | F | .. | .. |
| Randolph | F | .. | .. | .. | .. | .. | .. | .. |
| Richland | F | .. | .. | .. | .. | .. | .. | .. |
| Rock Island | 2 | 1 | .. | 1 | .. | P | .. | 3 |
| Saline | F | .. | .. | .. | .. | .. | .. | .. |
| Sangamon | F | .. | .. | .. | P | .. | .. | .. |
| Schuyler | F | F | .. | .. | .. | .. | .. | .. |
| Scott | F | .. | F | .. | .. | .. | .. | .. |
| Shelby | F | .. | .. | .. | P | .. | F | .. |
| St. Clair | F | 1 | F | .. | .. | .. | .. | 1 |
| Stark | .. | .. | .. | .. | .. | .. | .. | .. |
| Stephenson | .. | .. | .. | .. | .. | .. | .. | .. |
| Tazewell | F | .. | .. | .. | .. | P | .. | .. |
| Union | F | .. | .. | .. | .. | .. | .. | .. |
| Vermilion | F | .. | .. | .. | F | .. | .. | .. |
| Wabash | F | .. | .. | F | .. | F | .. | .. |
| Warren | .. | .. | .. | .. | .. | .. | .. | .. |
| Washington | F | .. | .. | .. | .. | .. | F | .. |
| Wayne | .. | .. | .. | .. | .. | .. | .. | .. |
| White | F | .. | .. | P | .. | F | .. | .. |
| Whiteside | F | 1 | P | .. | .. | .. | 1 | 1 |
| Will | F | .. | F | F | 1 | 3 | .. | 4 |
| Williamson | .. | .. | .. | .. | .. | .. | .. | .. |
| Winnebago | F | 1 | 1 | .. | .. | F | .. | 1 |
| Woodford | .. | .. | .. | .. | .. | .. | .. | .. |

F.—Favorable deposits present.
P.—Possible source; sampled.
5.—Number of producers of the kind of sand indicated.

adjacent to markets are sufficient to supply all needs. Loess deposits yield Type II sands. The occurrence of loess proper in workable thickness is indicated in Column 2 of Table 29.

## SLOPE-MANTLE DEPOSITS

Windblown sand and silt, mixed with sand and silt which has washed down the slope, often form deposits of Type III molding sand on the lower slopes of valley walls which are capped with loess. The occurrence of the slope-mantle deposits, Type III sands, is indicated in Column 3 of Table 29.

### SOIL-COVERED DUNES

Old dune deposits, or sand dunes which have a fixed soil, often contain sand with weathered bond and are of importance because such sand is Type I. Present methods of production change much of this sand to Type III. Old dunes necessarily occur relatively close to the original source from which the wind brought and concentrated the sand. Under present-day conditions the wind is shifting sand on river terraces and near beaches. Such areas are the most favorable for old dunes. The occurrence of molding sand in old dunes on terraces is indicated in Column 4 of Table 29.

In a few cases old dunes occur on the uplands. They were derived from sand deposits associated with glacial deposits. Like the old dunes on terraces, they contain Type I molding sand which may, in the process of production, be changed to Type III. Column 5 of Table 29 indicates the occurrence of these sands.

### STREAM-TERRACE DEPOSITS

Stream-terrace deposits are sands which were deposited in the channel or on the flood plain of a river at a time when either the river bed or the water level was higher than it is at present. Such deposits are essentially alluvium, but exceptional conditions may have produced a deposit relatively free from silt, from which subsequent weathering has removed the black "vegetable" bond and formed a red or weathered bond. Such deposits are commonly of Type III; although some parts of some deposits are Type I, such occurrences must be looked upon as rare exceptions. The occurrence of molding sands in stream-terrace deposits is indicated in Column 6 of Table 29.

### FLUVIO-GLACIAL DEPOSITS

Fluvio-glacial deposits which contain molding sand occur only in the drift ridges of Bond and Fayette counties. The deposits are large and yield an exceedingly uniform grade of Type I molding sand. Their occurrence is noted in Column 7 of Table 29.

## Adams County

The fine yellow silt or loess which caps the bluffs of the Mississippi comprises the only molding sand produced in this county. Loess may be seen capping the bluffs at many points, constituting the major part of the overburden of several stone quarries. On the lower parts of the slope, where rainwash is mingled with the windblown material, the fineness of the loess is often modified by coarser material. The loess is a calcareous Type II molding sand. Its utilization is largely dependent upon local demand.

It is improbable that coarser molding sands will be found in the county.

Two producers make use of the loess and its associated wash material, supplying local foundries only. The sand is used for a greensand for wheel work and as a bond renewer for coarser sands.

*Stratman pits, north edge of Quincy*

Mr. E. F. Stratman operates pits in the SW.¼ NW.¼ sec. 26, T. 1 S., R. 9 W., just north of Quincy. Leached slope-wash material containing pebbles makes up a 4- to 6-foot thickness on the lower slope. Loess is present on the upper slope. Several thousand tons are available.

*Platt pits, north edge of Quincy*

The pits of Mr. J. A. Platt are ⅛ mile northeast of the Stratman pits. Loess makes up the whole section, which has a maximum workable thickness of 9 feet. Sample No. 139 (see Table 30) was taken at the Electric Wheel Company, Quincy, where it is used for light gray iron casting and as a bond renewer. This is a calcareous Type II sand.

## Alexander County

No deposits of molding sand were seen in this county and there is small likelihood of the discovery of deposits of sufficient extent to merit development, although alluvial deposits, where sufficiently sandy, might be utilized locally.

*Ganister*

The weathered chart in the vicinity of Elco is mined by the International Silica Company of Cairo and the Tamms Silica Company of Tamms. That which is not pure white is discarded because of being off-color, and is, in some cases, shipped as ganister to the St. Louis market. A more distant market is hardly obtainable as the quartzite ganister, quarried on large scale in Wisconsin and in other localities, competes too strongly with the ganister mined by drifts in this county.

## Bond and Fayette Counties

These two counties are best considered as a unit, for their molding sand deposits are of the same origin and mode of occurrence. Figure 38 shows the location of the molding sand deposits of these counties.

Those ridges and hilly areas which are composed of thick glacial deposits of interbedded sands and gravels, comprise the favorable territory. The once-clean sandy gravel contains weathered clay bond, the percentage of clay being very high at the surface and gradually decreasing downward until clean sandy gravel is reached at a depth varying from 8 to 15 feet below the surface of the deposit. This weathered layer is thickest under the higher ground, where it makes up the thickness of the workable pit sections of natural-bonded molding sand. This bonded layer is so heavy that the sharp sand at the base is often utilized for mixing to open the sand. In all the pits the amount of bond in the sand may be varied, without contaminating the sand with silt, by taking only certain portions of the face or by mixing parts of the section. The relative fineness varies somewhat both horizontally and vertically, but the sand is so well sorted and contains such a small percentage of fine sand and silt that the average fineness of the sand produced remains remarkably uniform. The same is true between Mulberry Grove and Greenville. At Tamalco a strip some two miles long and one mile wide borders the valley of the river.

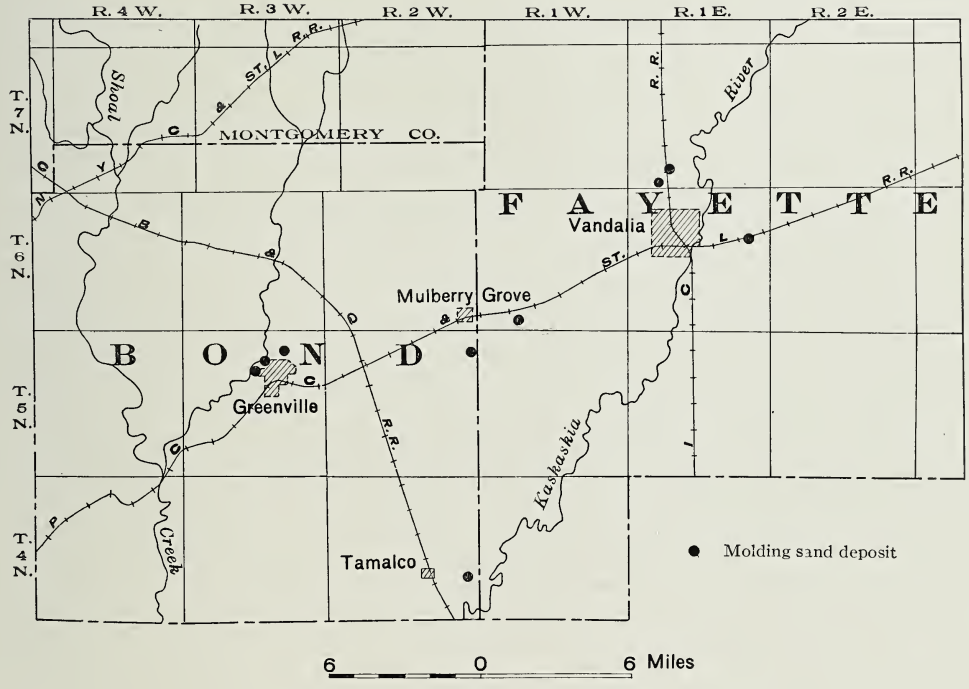



FIG. 38.—Map of molding sand deposits of Bond and Fayette counties.

Even though the deposits are widespread and generally continuous, the present available areas are limited to those within two miles of shipping points. On this basis there are four producing districts: the Vandalia area, including Bluff City; and the Mulberry Grove, Greenville, and Tamalco districts.

## VANDALIA DISTRICT

### *McKinney Bros. pit*

The pit of McKinney Bros., on the south side of the creek in the SW.¼ SW.¼ sec. 32, T.7 N., R.1 E., 3 miles north of Vandalia, is a nearly level terrace of glacial sand and gravel. The workable thickness of 15 feet, overlain by 2½ feet of clayey soil, is made up of sand and fine gravel containing relatively few pebbles, all quartzose. The top sand is very heavy and grades downward to sharp iron-stained sand at the bottom. Sample No. 163 (see Table 30) is a section of the pit face and represents pit run. The upper half of the face alone would be a much heavier grade and the lower half a more open grade. The fineness is uniform. This is a Type I sand, with high bond strength and permeability. The sand is hand-shoveled and wagon-hauled ⅛ mile to a spur of the Illinois Central Railroad. Possibly 80,000 tons have been removed and 200,000 tons are yet available on the property.

### *Mattes prospect*

Nearly half a mile west of the McKinney pit, on the property of Mr. J. Mattes, a prospective pit face had been cleared. The exposed thickness of 7 feet should increase as the pit is developed, although the overburden will also increase to 5 feet or more. Tree roots offer some hindrance to development. The face consists of sand and fine gravel with a variable amount of bond. The sand is apparently workable, although its prevailing quality can not be judged from so small an exposure. A large amount of sand is contained in the property, but as the difficulties of development will limit the available amount it is impossible to make an estimate.

### *State Prison Farm prospect*

On the State Prison Farm in the SW.¼ NW.¼ sec. 32, T.7 N., R. 1E., 3½ miles north of Vandalia, there is exposed below 2 feet of soil, a 9-foot thickness of stratified material, the upper 5 feet of relatively fine, even-grained sand, free from pebbles (Sample No. 162, Table 30), and the lower 4 feet of somewhat finer texture. Sample No. 161 (Table 30) represents the total 9-foot section. Both samples are Type I sands with high bond strength. It would appear that the section could be worked either in part or as a whole. A spur of the Illinois Central Railroad is adjacent to the exposure, so that loading might be direct. It is probable that 50,000 tons or more are available, but the texture and thickness of the beds may vary and reduce or increase that figure.

### *Stultz pits*

East of Vandalia 2½ miles, on the east bluff of Kaskaskia River, are the molding sand pits operated by Mr. Eugene Stultz. Two types of

molding sand are produced, the coarse red sand typical of the district and a finer, more open sand, which was the only sand of its type seen in either of the two counties. From 4 to 10 feet of the coarse red sand are exposed in pits in the lower slope of the hill. Sample No. 165 (Table 30), which represents pit run, is a very heavy Type I sand. Mixing with sharp sand at the base of the pit section permits a considerable range of bond strength. Scattered pebbles are present, but the percentage larger than ¼ inch is small. The finer sand, which is of windblown origin, and is found on the upper slope and on the flat top of the bluff, is represented by Sample No. 164 (see Table 30). The workable section varies in thickness from 2 to 6 feet and is underlain by sharp sand. This sand is a Type I sand having a very high bond strength and permeability. Sample No. 37 (see Table 30), a produced sand from the National Malleable Company, Chicago, is similar to No. 164. The sand is hand-shoveled and hauled by wagon and truck to the siding at Bluff City. At least 50,000 tons and possibly five times that amount are available of the finer molding sand, besides a considerable amount of the coarse red sand.

### MULBERRY GROVE DISTRICT

#### *Coarse Red Molding Sand Co. pit*

The pit of the Coarse Red Molding Sand Company is located near the center of sec. 32, T.6 N., R.1 W., 2½ miles east of Mulberry Grove. Some five acres, on the slope of the creek valley, have been almost worked out during the last 16 years. The present pit is located on the higher ground and exposes a workable thickness of 9 feet below 3 feet of overburden. The face consists of coarse sand with a very little fine gravel and is practically free from pebbles. Bond distribution is gradational vertically, the heaviest sand being at the top. Sample No. 169 (see Table 30) represents pit run of the total section. Like the other sands, this is a Type I sand. The sand is hand-shoveled and hauled by truck to the Pennsylvania Railroad siding 1½ miles west. The glacial gravels underlie many acres adjacent to the pit property. If all of the weathered layer consists of workable sand, several hundred thousand tons are available.

#### *Abandoned pits east of Mulberry Grove*

A mile east of Mulberry Grove, on either side of the Pennsylvania Railroad, are abandoned pits. The pit to the north was abandoned because further development endangered the State Road grade. The pit to the south of the track contains a 6-foot thickness of workable sand, but the available supply is small.

#### *Warren Sand Co. pit*

The Warren Sand Company's pit, 1¼ miles south of Mulberry Grove, exposes an 8-foot section (fig. 39). The face is made up of coarse sand and fine gravel with very few pebbles. Sample No. 168 (see Table 30), taken from partially loaded cars, is a Type I sand with considerable silt, which suggests too shallow stripping. Sample No. 100 (see Table 30) from this pit, collected from the bin of the Franks Foundries Corporation,

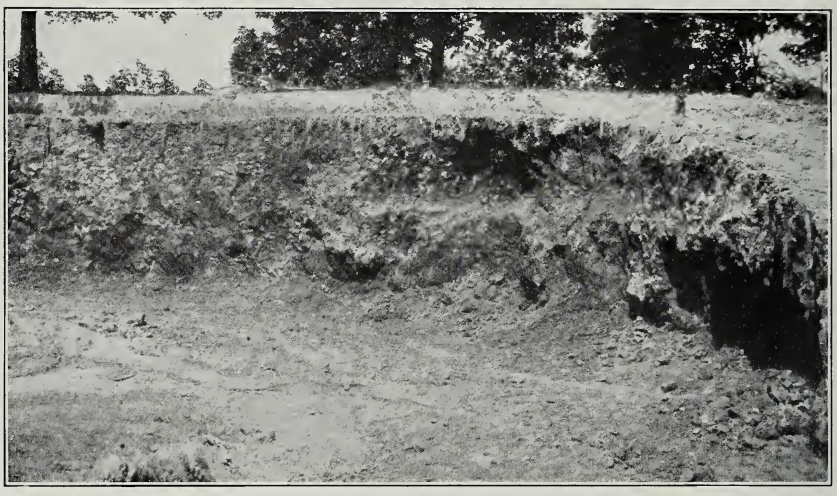


FIG. 39.—Molding sand pit face operated by Warren Sand Co., 1¼ miles south of Mulberry Grove, Bond County

FIG. 40.—Molding sand pit face operated by G. Nicol and Son, 1½ miles east of Tamalco, Bond County.

Moline plant, has the same silt-clay ratio with a lower clay percentage. The optimum water content is lower, but bond strength is about equal and natural permeability is much higher. These are minor variations and the two samples well illustrate the uniformity of the deposit. The face is shot down and the sand hauled by wagon to Mulberry Grove. At least 80,000 tons are available if the thickness and quality remain constant.

GREENVILLE DISTRICT

*W. M. Peterson and Sons pits*

The pits operated by W. M. Peterson and Sons are located on the southeast slope of the creek valley in sec. 10, T.5 N., R.3 W., half a mile from the Pennsylvania Railroad siding in Greenville. The thickness varies from 3 to 10 feet, and the fineness, in any one pit, is fairly uniform. The many exposures revealed that horizontal variability in fineness is marked. A vertical change from sand to fine gravel occurs in some places. Clay is distributed gradationally from the top downward. The pit run of the pit in operation when visited, is indicated by Sample No. 170 (see Table 30), which was taken from a partly loaded car. This sand is on the border line between Type I and Type III because of its high silt content and evenly distributed grain. The difficulty of mixing and maintaining a uniform product under conditions of varying fineness is partly offset by the advantage of varying, within limits, the fineness of the products to suit a variety of needs. The product is hand-shoveled and wagon-hauled. It is impossible to make an estimate of available sand, but it is certain that this tract is far from worked out.

*Ed. B. Squier Co. pit*

The pit of the Ed. B. Squier Company is located in the SW.¼ sec. 2, T.5 N., R.3 W., 1½ miles from the siding in Greenville. A face varying from 5 to 8 feet, capped by 3 to 5 feet of clay, constitutes the working section. There is the common range of bond, the sand becoming sharper from the top downward. In addition there is some horizontal variation in fineness. Sample No. 171 (see Table 30 and figures 28 and 30) represents the total section. It is a very coarse Type I sand with exceptionally high natural permeability. Samples No. 52 and 53 (see Table 30) were taken in the foundry of Greenlee Bros., Rockford. Sample No. 52 is of finer texture than No. 171 and is a Type I sand. Sample No. 53 is almost identical in texture except for the presence of more than 10 per cent more silt; the silt decreases its bond strength about ¼, its natural permeability almost ½, and its base permeability more than ¾. Sample No. 52 is a good example of a Type III*a* sand, made by mixing fine material with pit-run Type I sand. The sand is hand-shoveled and hauled by truck to Greenville. It would appear that considerably more than 100,000 tons are available, but the variable nature of the deposits in the Greenville district make estimation difficult.

*Garden City Sand Co. pit*

A small pit operated by the Garden City Sand Company is located in the southeast bluff of the creek, in the NE.¼ sec. 10, T.5 N., R.3 W., half

a mile northwest of Greenville. The thickness does not average more than 4 feet, but further development should meet with increased thickness. Large pebbles are present and the bond is very heavy, necessitating the addition of the sharp sand from the base of the section. Further development is needed to prove the quality of this deposit.

### TAMALCO DISTRICT

#### *G. Nicol and Son's pit*

The pit operated by G. Nicol and Son (fig. 40) is located 1½ miles east of Tamalco, adjacent to the north line of sec. 25, T.4 N., R.2 W. The maximum thickness is 10 feet and some parts of the face are much less. Coarse sand, fine gravel, and scattered pebbles, with the bond decreasing in amount from the top downward, make up the section.

Waste is eliminated in the production of the heavier bond grades by the use of faces opened to the desired depth. For the more open grades the sharper sand exposed at the base of the total section is available. Sample No. 166 (figs. 28 and 29, and Table 30) represents the heavy material from the top 6 feet of the section. Sample No. 167 is a half-and-half mix of the top 3 feet and of the sharp iron-stained sand from the base of the section. As is common, the mixed sample contains much more silt than the produced grade. Sample No. 179 (fig. 28) is from the bin of the Enterprise Foundry Company, Belleville. It is almost identical with No. 166 and is illustrative of the uniformity of the deposit.

The sand is hand-shoveled and hauled by truck to Tamalco. There is an area of about 20 acres underlain by the sand, which, if of the same quality and thickness as that exposed in the pit, would total some 400,000 tons.

### Boone County

It is unlikely that molding sand will be found in any part of Boone County except in the deposits associated with the streams. The terraces along Kishwaukee River are of gravel with little or no overlying sand. The valleys of Beaver, Coon, and particularly Piscasaw creeks, are possible areas in which large deposits might be found.

#### *Stream terraces of Piscasaw Creek*

In the NW.¼ NE.¼ sec. 24, T.45 N., R.4 E., 3½ miles southwest of Capron, a six-inch layer of very good molding sand is exposed in the bank of Piscasaw Creek. Two to three feet of sand, containing very thin silt partings, with a two-foot overburden, are present in the south bank of the creek just west of the line between secs. 26 and 27, of the same township. Sample No. 43 (see Table 30), collected at this point, is a good-quality Type I sand. The silt content of this deposit will vary horizontally as the deposit is a stream terrace. Between 20,000 and 40,000 tons are available.

South and west of this point, on the flat plain which constitutes the terrace, a 2- to 3-foot thickness of light-yellow silt lies directly beneath the soil and above coarser sand. It is possible that this material might be

suitable for molding sand in some places. These deposits are a considerable distance from a shipping point and profitable development would necessitate machine- or scraper-digging and motor-hauling.

## Bureau County

The molding sand deposits of Bureau County are limited to relatively small areas (fig. 41). All are windblown sand deposits which mantle hill slopes and which are not topographically evident. However, they are dome-shaped and are classified as upland dunes. The sands produced are of uniform fineness and contain weathered red clay bond, which is distributed in clayey layers with sharp sand between. A layer of silty clay 1 to 1½ feet in thickness overlies the sand. The contact is gradational, there being about 6 to 8 inches of sandy silt. If stripped below this zone, such a deposit is favorable for the production of Type I sand, but if part of the overburden is included the sand produced will be Type III*a*. As the fineness of the sand varies but little, grades of commercial bond content are made by the addition of the silty surface clay or the basal sharp sand. Sand is shipped from Wyanet and Buda.

### *Golden and Larson Company pits*

The Golden and Larson Company operate several pits in the SE.¼ sec. 21, T.16 N., R.8 E., a mile southeast of Wyanet. The pit faces have an average thickness of about 4 feet; the fineness is uniform; and the silty surface clay which underlies the soil is added to increase the bond strength. Sample No. 113 (see Table 30) is pit run of one face which was being worked. It is a Type III sand. It would appear that at least 100,000 tons are yet available, although many thousand tons have been removed during past years.

### *Roadcut exposures*

A 2-foot section of molding sand is exposed at several points along the road which bounds secs. 17 and 20, T.16 N., R.8 E., ¼ to 1¼ miles west of Wyanet. The bond is not constant and the thickness is hardly sufficient to merit development. No sand was seen on the east side of Bureau Creek, east of Wyanet.

### *Westervilt pit*

A mile east of Buda in the NW.¼ sec. 35, T.16 N., R.7 E., is a deposit of molding sand (fig. 24) which is worked by Mr. Jesse Westervilt. The maximum thickness is 4 feet. The fineness is uniform. Bond grades are made by including more or less of the clayey layer at the top. Sample No. 116 (see figs. 34 and 35, and Table 30) is pit run and No. 117 is a sample taken from a dug hole some 200 yards from the pit face. They indicate the uniformity of the deposit. These sands are just on the border line between Types I and III. A closer stripping of the surface clay would yield a weaker, more open, Type I sand. Some 60,000 tons are available.

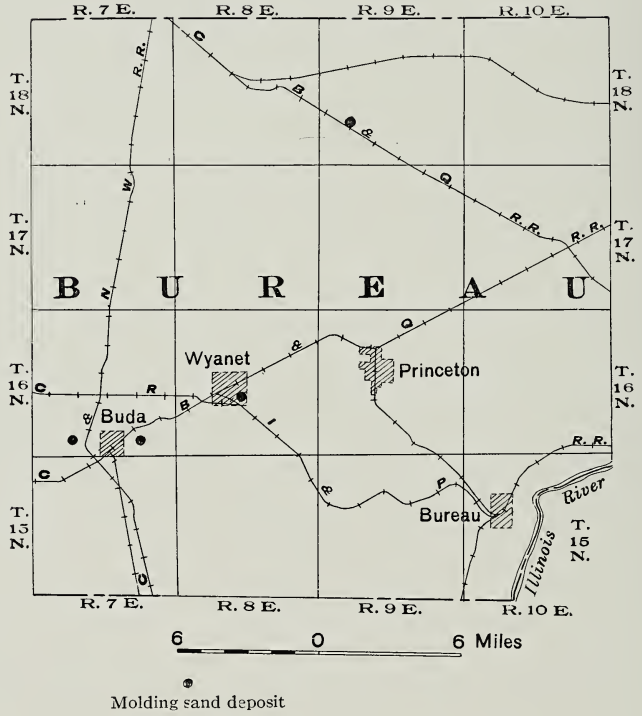



FIG. 41.—Map of molding sand deposits of Bureau County.

### *Lay pits*

Mr. Lay operates pits in the north center of sec. 33, T.16 N., R.7 E., three-fourths mile west of Buda and in the NW.¼ sec. 32, 1½ miles west of Buda. Sample No. 115 (see Table 30) is a produced grade. Sample No. 114 included the surface clay. The maximum bond is much the same, but the heavier sand has a higher optimum water content and more uniform bond strength, throughout the working range. The permeability is of the same degree. The amount of workable sand available is considerable but is difficult to estimate. The pits in the NW.¼ sec. 32 contain a 3- to 5-foot thickness of workable sand. The bond is distributed in uniform clayey layers between which are layers of sharp sand. The texture being nearly uniform, grades are made on bond content. At least 40,000 tons are available at the latter location and it is probable that several times that amount is present in the vicinity.

## Carroll County

No workable deposits of natural-bonded molding sand were seen in Carroll County, although considerable areas lying mostly in the Mississippi valley and along its bluffs contain sand and for that reason are possible areas.

There is an abundance of sharp sand on the terraces of the Mississippi. Auger borings indicate that several 6-inch layers of molding sand are sometimes found at a depth of 6 to 8 feet. The most probable area is along the Chicago, Milwaukee and St. Paul Railroad from a point a mile south of Savannah to the Whiteside County line. Any deposit of workable thickness found in the valley will be overlain by at least 3 feet of sharp sand. The light-yellow loess is common on the bluffs south of Savannah but none of the deposits could compete with the more available locations in other counties. The small areas of sand in the south-central part of the county are of no value for molding sand.

## Cass County

The lower slopes of the east valley wall of Illinois River are the only areas in Cass County favorable for molding sand. The broad terrace is surfaced in places with shifting sharp sand and the presence of bonded sand is improbable. However, the sandy flat is the source of the sand which has been blown up against the slope, mixed with slope-wash, and weathered until it is a natural-bonded molding sand.

### *G. Nicol and Son's pits*

One company, G. Nicol and Son, operates pits in Cass County. Two pits are worked in a large deposit which extends irregularly some two miles north from Arenzville along the lower slopes of the valley wall. The sand is all Type III, as the variability of the section is unavoidable, considering the varying degrees of steepness and direction of face of the slope. In general the coarsest sand is near the base of the slope, but this could only be true if the slope was a tilted plane and the depositing agent

a wind of constant velocity and direction. In addition, much finer material is mixed with the sand because of slope-wash during the deposition of the sand. It is quite evident that the maintenance of uniform grades is entirely in the hands of the producer.

Samples No. 143 and 144 (see Table 30) represent the coarsest and finest phases seen in one of the pits, one-half mile north of Arenzville siding and the Chicago, Burlington and Quincy Railroad. Sample No. 143 is a Type I sand, but as a producible grade it would be of slight extent. This part of the deposit has from 50,000 to 120,000 tons of available sand. Sample No. 145 comes from the face of another pit and is from the upper 4 feet of a 5½-foot section. Sample No. 146 is from the lower 1½ feet. It contains lime concretions which entirely make up the 40-mesh grade, and are scattered through the finer grades. It is of no value as a molding sand and must be kept out of produced grades. Some 30,000 tons are in this part of the deposit. Sample No. 177, from the Eagle Foundry Company, Belleville, and No. 138, from the Electric Wheel Company, Quincy, are samples of produced sands. Both are good examples of fine-textured Type III*b* sands.

*Bluff Springs unworked deposit*

Sample No. 147 (see figs. 34 and 36, and Table 30), representing a very fine Type IIIb sand, was taken from an unworked deposit in NE.¼ NW.¼ sec. 27, T.18 N., R.11 W. The sample was mixed from several channels of a 2- to 4-foot section which is extremely variable vertically. It is doubtful if molding sand can be produced from this deposit, for though the sand is fine, it contains too high a ratio of coarse sand for smooth work. The total extent is 14,000 to 35,000 tons.

## Cook County

No commercially valuable deposits of molding sand were seen in Cook County (see fig. 43) and there is no record of any production during the current year. Sharp sand is abundant as old dunes and beach deposits, but sand containing bond is lacking. Considerable attention was given to this area, but only two prospects, of doubtful value, were seen.

*Willow Springs*

A mile southwest of Willow Springs in the NW.¼ sec. 7, T.37 N., R.12 E., in the south valley wall of Des Plaines River, a stratified deposit of fine gravels, sands, and silts is exposed. Some of the silty layers might be utilized should they occur near the surface.

*Westernmost townships*

The two westermost townships are the most probable areas in the county, but there is small possibility of discovery of workable deposits.

On the farm of Mr. Henry Louis (fig. 43), 4½ miles southwest of Barrington, in the NE. ¼ SW. ¼ sec. 9, T. 42 N., R. 9 E., there is exposed a three-foot layer of an excellent Type I sand (Sample No. 10, Table 30). Overburden 3 to 5 feet thick is present, and the distance from a shipping point seems prohibitive of development.

## De Kalb County

### *Kishwaukee River deposit*

The only probable area for molding sand deposits in De Kalb County is along the South Branch of Kishwaukee River. The terraces on both sides of the river, in sec. 23, T. 42 N., R. 3 E., contain some coarse open sand, but no workable deposits were seen. Evidences of molding sand were seen along the line between secs. 32 and 33, T. 42 N., R. 4 E., but the patchiness of the deposits and distance from a shipping point are unfavorable for development. The area is well worth prospecting with a view to discovering extensive deposits of coarse-textured, rather open sand.

## Du Page County

No workable deposits of molding sand were seen in Du Page County and it is not probable that any deposits will be found. The most favorable area is the northwest part of T. 40 N., R. 9 E., the northwest township of the county.

## Gallatin County

### *Wabash River terrace*

The broad terraces of Wabash River do not seem favorable for molding sand. The sand is so intimately mixed with silt, and is vertically and horizontally so variable that there is little prospect of the discovery of molding sand in the waterlaid terrace sands. The windblown sands derived from the terrace are of much more value, as they are well sorted (see fig. 49B). The establishment of a soil and the subsequent weathering of the sand furnishes a bond.

### *Shawneetown Hills*

Old dunes were not seen in Gallatin County, but windblown sand derived from the flat to the west mantles the lower slopes of the west face of the Shawneetown Hills. The deposit has a gross content of 128,000 to 700,000 tons. The south end of the deposit extends to and across the right of way of the Louisville and Nashville Railroad in the SE. ¼ SW. ¼ sec. 21, T. 9 S., R. 9 E., one mile east of Junction siding. A 6-foot section of bonded sand was exposed on the road which parallels the track at this point. Sample No. 190 (see Table 30) was taken from the upper two feet and Sample No. 191 from the lower 4 feet of the section. Both are Type III sands, and it is hardly probable that the deposit is capable of producing Type I sand, as it is subject to the variations common to windblown deposits on slopes. The uncommon size and thickness of this deposit make it of considerable value even though the chances of obtaining uniform production are small.

## Grundy County

No workable deposits of molding sand were seen in Grundy County but there is some possibility of the discovery of more or less extensive deposits. (See fig. 43.)

Those areas, as Sand Ridge, in sec. 16, T. 34 N., R. 8 E., which are covered with sharp sand are not especially favorable, as whatever molding sand may be present is covered by several feet of sharp sand which makes the deposit difficult of discovery and expensive to develop. Northeast of Eileen, located in sec. 35, T. 33 N., R. 8 E. there is an area covered by sands and silts in which molding sand might be found, but the probability of workable deposits is small. The most favorable area is the beach of old Lake Morris. This beach area is mapped in the report on the areal geology of the Morris quadrangle[1]

The beach deposits are not in themselves valuable, but windblown deposits derived from them and now covered by vegetation, may contain molding sand. The best locations should be east of a well-developed beach deposit, preferably near a point where a stream now crosses the beach deposit.

*Mazon River terraces*

Stream terraces bordering Mazon River and its tributaries are of promise, particularly between the Sante Fe and the Big Four railroads and the Chicago and Alton Railroad. The terrace on the north side of the river at the bridge in the south part of sec. 13, T. 32 N., R. 7 E., 2½ miles east of Mazon, showed a thickness of 2½ feet of Type III sand. The extent is probably slight and the quality variable.

## Hancock and Henderson Counties

Hancock and Henderson counties (fig. 42) are best considered together as their molding sand deposits are of similar origin.

In general, the deposits are to be found at the base, on the slopes, or on the crest of the bluffs and all are the result of wind deposition although slope-wash has in some cases modified the deposits.

Two types of sands are produced: Type II, or the fine yellow silt, and Type III*b* which includes both the red slope-mantle sands and the black slope-wash sands. The Type II sand is abundant and workable thicknesses may be found at many places along the bluffs. The red sands are less evident, because they mantle the lower slopes; and, because of their variability, they are not always workable. The black sands are directly derived from the slope mantle, being wash from gullies which cut the lower slopes. Thorough prospecting must be done in order to determine the value of a deposit. Gladstone, Lomax, and Dallas City are shipping points.

### Gladstone district

*Monmouth Stone Co. pits*

The deposit of the Monmouth Stone Co. is located near the center of sec. 11, T. 10 N., R. 5 W., 1½ miles northeast of Gladstone. The molding sand constitutes a part of the overburden of a limestone quarry. Both the fine yellow silt or loess and the red slope-mantle sands are present, and in addition core sand may be obtained in some places. The loess

[1]Culver, H. E., Geology and mineral resources of the Morris Quadrangle: Ill. State Geol. Survey Bull. 43, p. 86, 1922.

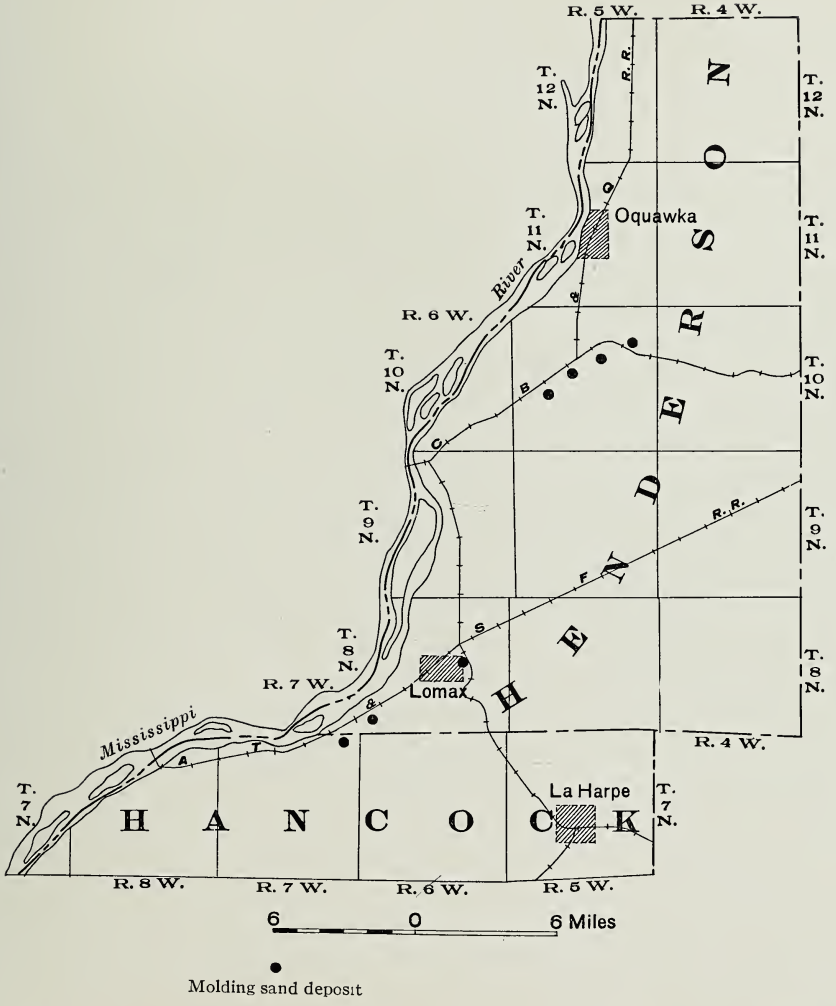



FIG. 42.—Map of molding sand deposits of Hancock and Henderson counties.

has a maximum thickness of 15 feet and is calcareous throughout. The slope-mantle sands are somewhat variable in fineness. Sample No. 131 (see Table 30) represents the pit run of a 6-foot section. Sample No. 142 (figs. 34 and 36, and Table 30) is a produced grade from the same section, taken from the bin of the Gem City Stove Co., Quincy. The samples are quite similar in fineness, but the heavier shows more clay, a higher optimum, and more uniform bond strength, combined with a higher natural permeability. The influence of silt is clearly shown in the lower base permeability of the heavier sand. Some 5,000 tons are available. Several thousand tons of core sand are available west of the quarry.

### *Graham pit*

At the top of the bluff, ¼ mile east of Gladstone, a 16-foot section of loess is worked by Mr. W. H. Graham. Lime concretions are plentiful near the base, and the greater part of the section is calcareous. Sample No. 128 (see Table 30), a Type II sand, is representative of the loess. Core sand is produced from a deposit on the slope.

### *Galbraith pit*

A fine black sand is dug by Mr. J. T. Galbraith from a slope-wash deposit at the bluff base ½ mile south of Gladstone. A pit face of 6 feet is worked; the fineness varies from silt to sand with a bond of black clay. As the source from which the material was washed was the bluff deposits of sands and silts, the fineness is variable within these limits and a Type III*b* sand results. Sample No. 130 (see Table 30) is pit run taken from a loaded car. It is probable that workable sand underlies at least 2 acres, 2½ miles southwest of Gladstone.

Near the center of sec. 20, T. 10 N., R. 5 W., the road cuts through a low terrace dune which contains 1 to 3 feet of a slightly coarser Type III*b* sand (Sample No. 132, Table 30). The deposit does not contain more than 3,000 tons and it is doubtful if it could be profitably worked. There is a possibility that other similar deposits containing this type of sand may be present on the broad terrace.

## LOMAX DISTRICT

### *Camilla Sand Mines Co.*

Half a mile east of Lomax, near the top of the bluff, is a 9-foot section of loess which is worked by the Camilla Sand Mines Co. The section is calcareous and is the yellow Type II sand common along the bluff crests.

## DALLAS CITY DISTRICT

### *Purity Molding Sand Co. pits*

Type III molding sand is obtained by the Purity Molding Sand Co. on the slope of the bluff in the NW. ¼ SW. ¼ sec. 31, T. 8 N., R. 6 W., Henderson County, 2 miles northeast of Dallas City. The deposit mantles the slope, the coarser and heavier sands near the base grading upward into a finer, more open type. The variation between the coarsest and finest

sand is not great, and warrants only two grades based on fineness. The quantity of the red-clay bond present in each grade may be varied considerably, hence there may be two bond grades of each fineness grade (Sample No. 133, No. 2 open, and Sample No. 134, No. 1 open, Table 30). The maintenance of these grades is dependent upon the judgment used as the sand is dug. A combination muller and car loader is used. Nos. 86, 101, and 176 (Table 30) are samples taken at foundries. The producer's grade number was not ascertained. It will readily be seen that in these sands the percentage of clay has relatively little effect upon the bond strength, which seems largely due to the silt in both silt and clay grades. The fact that the percentage of silt has a very important relation to the permeability is recognized by the producer, inasmuch as grades are made on permeability, for the bond strength is usually sufficient for the light work for which the sand is used. At least 30,000 tons are available and prospecting will no doubt discover more.

Just east of Dallas City, a similar deposit of red-bonded sand, smaller in extent, is worked by this company (Sample No. 137, Table 30). Loess banks, from which two grades of Type II sand are produced, are located just east of the loading plant, in Dallas City. Sample No. 149 (Table 30) is of this type. A large amount of loess is available.

### *Other deposits*

No detailed search was made for new deposits, but it was apparent that there is a considerable acreage as yet undeveloped. Much of this is now too far from transportation and the lack of uniformity of other deposits precludes their use.

It is possible that workable molding sand may be found along the bluffs near Hamilton, sec. 30, T. 5 N., R. 8 W.

## Henry County

The terraces of Green River contain the only workable molding sand deposits seen in Henry County (fig. 48). Those deposits near the mouth of Green River have been developed to a considerable extent, but farther east, between Green River and Geneseo, there are other deposits which should furnish quantities of excellent molding sand.

The molding sand now produced is Type I and Type III medium-textured sand with a red-clay bond. It is taken from wind blown deposits which occur on the terraces and from slope mantles on the adjacent slopes. The lower terrace, at some points, contains a finer grade of sand with a yellow clay bond. This material has not been utilized as yet. The higher ground, particularly that lying between Green and Rock rivers, is mantled with loess, which is not utilized, as this type of material occurs in more favorable locations nearer markets.

### *Oberlaender pits near Colona*

The molding sand pits of the C. E. Oberlaender Co. are located on the top of the upper terrace ¼ mile north of Colona. The terrace itself is made up of sharp sand, utilized as asphalt sand, which is of remarkably uniform texture throughout the 15-foot section.

The relative fineness of the molding sand in the deposit is variable between well-defined limits, but the silt and clay contents are extremely variable. The maintenance of uniform grades is dependent upon the skill of the producer, as some mixing must be done at all times. The cars are loaded by machine loader which also mulls the product. Samples No. 77 and No. 76 (Table 30) were taken from pit faces, and Samples Nos. 83, 88, and 89, from foundries. All five are Type III sands in which permeability is a greater variable than bond strength. It is impossible to estimate the extent of this deposit.

### *Other deposits near Colona*

An intermediate terrace remnant east of and at the level of the town of Colona may contain molding sand. On the lowest terrace, in the SW. ¼ sec. 11, T. 17 N., R. 1 E., a mile south of Colona, are widespread molding sand deposits. The workable material is in low dunes, which are almost continuous over the area. The thickness of the workable sand varies from 1 to 3 feet. In some parts of the deposit there are two sands, coarse and fine, one above the other. The clay content is ample for the production of several bond grades, utilizing the sharp iron-stained sand which underlies the molding sand. Samples Nos. 93, 94, and 95 (Table 30) are representative of producible grades. The amount of this sand available on the terraces of the lower part of Green River is probably hundreds of thousands of tons.

### *Terrace dunes near Green River Station*

Formerly a pit was worked in the SE. ¼ sec. 7, T. 17 N., R. 2 E., half a mile southeast of Green River. The bond is variable in the 4-foot section exposed. The bonded sand is in bands between which are layers of sharp sand. The varying thickness of these layers varies the proportions of sharp and heavy so that a uniformly bonded product would be difficult to obtain. Sample No. 112 (Table 30) represents a "50-50" mixture of sharp and heavy sands. It is a Type I sand. A large amount of this type of sand, variously bonded, is available, not only at this location but at many other places on the intermediate terrace.

### *Stream terrace east of Green River Station*

Four miles due east of Green River in the SW. ¼ sec. 10, T. 17 N., R. 2 E., between the Chicago, Rock Island and Pacific Railroad and the scarp of the intermediate terrace, there is a deposit of fine sand with a lime-free yellow clay and silt bond. A 3-foot thickness was found in several places and it seems probable that this thickness prevails. Sample No. 111 (Table 30) represents the total section in one exposure. If the thickness is uniform there are about 200,000 tons in this tract. Undoubtedly more may be found in the same vicinity. This sand is a waterlaid Type II sand, and, if not too strong, may prove of value for stove-plate work. It is quite probable there are deposits on the Green River terraces to the northeast of Geneseo, but these are too far from transportation at present prices.

## Jackson County

The flood plain of the Mississippi in Jackson County is not a favorable area for molding sand, as the alluvium is not uniform and old windblown deposits are absent. Exceptional conditions are responsible for the only deposit in the valley proper of the Mississippi seen between St. Louis and Cairo.

### *Deposit at Sand Ridge*

The channels of the Big Muddy and the Mississippi are separated by a stream-terrace remnant on which the surface sand is being shifted by the wind into ridges. Beneath this shifting layer is a uniform 4- to 6-foot thickness of molding sand. Auger borings disclosed its presence in several places, but there was some difficulty in finding an exposed section, as the terrace edges have been beveled by the wind. A section was found in the Illinois Central Railroad cut in the northeast edge of the town of Sand Ridge, SW. ¼ NE. ¼ sec. 16, T. 9 S., R. 3 W. Sample No. 182 (Table 30) was taken from the total 6-foot section. The sand is Type III, and contains a few pebbles, is a waterlaid deposit, and is subject to both horizontal and vertical variation. Auger borings showed it to be fairly uniform in fineness. The extent is between 60,000 and 480,000 tons. It is not probable that other deposits occur in the county.

## Jo Daviess County

### *Einsweiler pits near Gears Ferry*

F. Einsweiler and Sons are the only producers of molding sand in Jo Daviess County, with pits at Gears Ferry and at Aiken. The Gears Ferry pits are in the NE. ¼ NW. ¼ sec. 35, T. 28 N., R. 1 W., some three hundred yards from a siding on the Illinois Central Railroad, at the top of a bluff accessible only to wagons. The pit is in loess, which is somewhat sandy because of its proximity to the valley from which a part of the material was derived. The upper 2 feet of the 6-foot thickness is used as fire clay, and the lower 4 feet is uniform-textured, fine, yellow sand which in some parts of the pit is so heavy that it is used as fire clay. The textural range of the material is small and the heaviness restricts its use as a greensand but increases its value as a bond renewer. At least 15,000 tons are available in this deposit and there are other deposits of a similar nature capping the bluffs to the north, although most are extremely difficult of access.

### *Einsweiler pits near Aiken*

Other pits operated by F. Einsweiler and Sons are located ⅛ mile west of Aiken on the south side of the Chicago Great Western Railroad tracks. A thickness of 3 to 4½ feet is worked, the lower 1½ feet of which (Sample No. 62, Table 30) is of medium fineness and is open. The upper 3 feet is finer and heavier and constitutes a different grade (Sample No. 61, Table 30). Both are Type III sands although No. 62 is very nearly Type I. There is some variability in fineness and the land is partly timbered, so that a large output of a strictly uniform grade is not practicable. Little more than 25,000 tons are available although the terrace extends

from the Chicago, Great Western Railroad bridge over Smallpox Creek to a point about ¼ mile west of Aiken and south from the tracks to the creek.

*Other deposits*

To the south a terrace remnant extends along the Chicago, Burlington and Quincy Railroad from the Smallpox Creek bridge to the limestone bluffs. A larger remnant about ¼ mile wide lies along the same railroad, for a distance of 3 miles southwest of Blanding. No workable sand was seen on these remnants but they are possible areas.

*Loess deposits near Rice Station*

Extensive deposits of loess cap the ridge at the cross roads in the center of the W. ½ sec. 23, T. 27 N., R. 1 E., 1¼ miles south of Rice Station. Because of its lime-carbonate content, there is but small demand for this kind of Type II sand. The texture is remarkably uniform, and Sample No. 63, Table 30, from an 8-foot section, is representative of the texture and bond. There are more than a million tons of this material within 1½ miles of the station and the thickness of 5 to 15 feet is sufficient for scraper digging.

## Kane County

On the basis of the occurrence of molding sands, Kane County (fig. 43) may be divided into three parts.

1. The terraces and valley-wall slopes of Fox River. The territory east of the river is the more favorable.
2. The northern half of the county, exclusive of the river valley. The deposits are exceedingly variable and may occur far from transportation.
3. The southern half of the county exclusive of the river valley. No workable deposits were seen in this area and their occurrence is improbable.

A large amount of sand has been taken out and such development is due, not only to abundant resources but also to the more thorough prospecting which comes from the presence of men who are familiar with sand. The sand is all Type III*b* because of the high silt percentage which was undoubtedly primarily deposited. A part of the clay bond is also primarily deposited, but much of it is due to weathering.

*Stewall farm and associated deposits south of Algonquin*

Adjacent to the north line of the county, a terrace deposit extends from the SW. cor. sec. 3, T. 42 N., R. 8 E., to Algonquin in McHenry County. The deposit is variable and the coarser, more open sand is contained in the low broad swells. The pit of the Garden City Sand Co. (see McHenry County description) is in the northward extension of this deposit. Sand was formerly taken from the farm in the W. ½ NE. ¼ sec. 3, T. 42 N., R. 8 E., now owned by Mr. B. B. Stewall, but this part of the deposit is considered to be worked out.

*Vogel pits, near Carpentersville*

In the SW. ¼ NE. ¼ sec. 15, T. 42 N., R. 8 E., a deposit of sand is worked by Mr. Frank Vogel. The deposit is variable to some degree but

as several wagon pits have been opened a nearly uniform product is possible. Sample No. 8 (Table 30) is a mixture taken from several pits. Possibly 13,000 tons are available but the presence of trees makes the working of a part difficult.

A mile west of Carpentersville on the property of E. H. Moore in the SW. ¼ sec. 16, T. 42 N., R. 8 E., a deposit of sand is worked by Frank Vogel. The sand lies along a ridge and while its texture and bond are exceedingly variable, small areas of the sand are workable. About 8,000 tons are available adjacent to the present pits and exposures of workable sand in roadcuts indicate that probably still more sand is available in the mile to the west. The production of a uniform grade year after year from such a deposit is difficult. Sample No. 7 (Table 30) was taken from a partly loaded car.

*Richardson farm and vicinity near Dundee*

A patchy deposit which lies at the brink of the slope of the valley wall extends from the east part of Dundee almost to the south line of sec. 26, T. 42 N., R. 8 E.. It is best developed on the farm of Mr. J. H. Richardson, near the north line of the section, where a 7-foot thickness is present. The variability in texture, both horizontal and vertical, would make development difficult.

*Deposit west of Elgin*

Sand was formerly taken from sec. 15, T. 41 N., R. 8 E., in the west edge of Elgin and at least one small tract was completely worked out. Growth of the town makes further development impossible.

*Van Wicklin pits south of Elgin*

A deposit of molding sand in sec. 1, T. 40 N., R. 8 E., underlain by gravel, coats the slope of the east valley wall of Fox River. Near the east edge of the deposit are the pits of J. G. Van Wicklin. The thickness varies from 3 to 5 feet, which is divided into two rather distinct layers, the lower being the heavier. These are loaded as separate grades and a considerable mixing range is possible. Sample No. 2, Table 30, was taken from a partly loaded car and represents the pit run of the finer grade. Sample No. 38 (Table 30) from the International Harvester Co., Chicago, is a coarser, more open grade. The sand is hand-shoveled into wagons and loaded on a spur of the Chicago and Northwestern Railroad, which is on the property. During the 18 years prior to 1923, some 60 acres have been worked out by this company. At least 60,000 tons are yet available. No more workable sand was apparent between the Van Wicklin deposit and the north edge of Aurora.

*Sperry Co. pits near North Aurora*

The Sperry Co. of North Aurora digs sand for use in their own foundry from pits a mile north of North Aurora between the road and the river. The sand is relatively fine and occurs in a 2-to 3-foot thickness. Sample No. 6 (Table 30) was taken from the foundry bin.

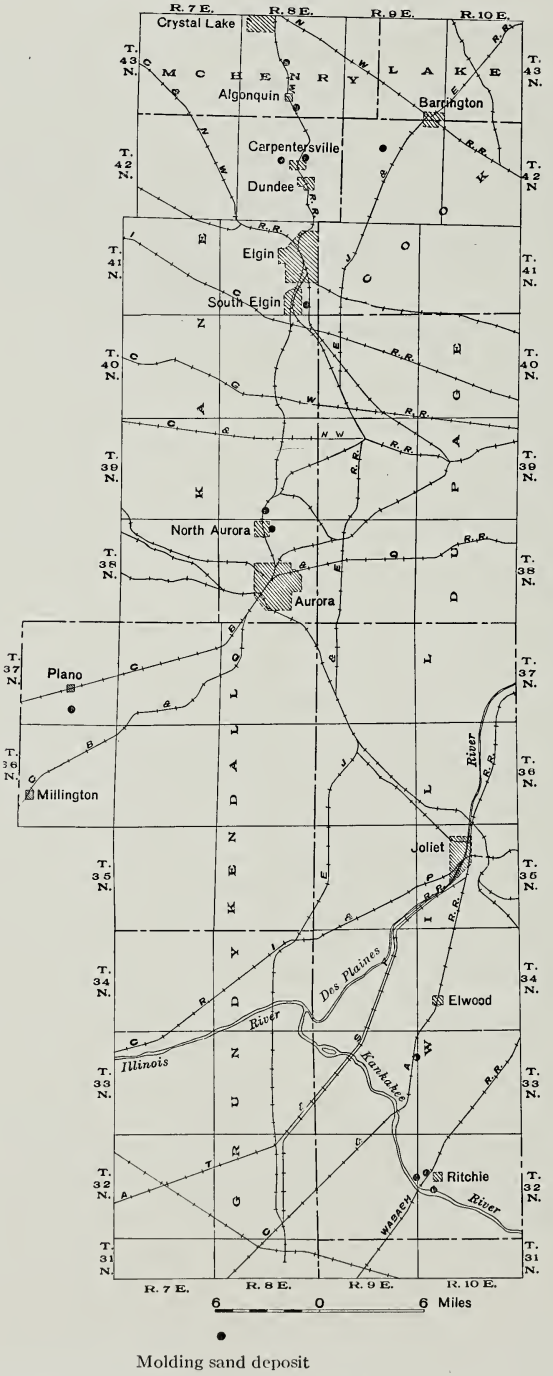



FIG. 43.—Map showing molding sand deposits of McHenry, Kane, Cook, Kendall, Grundy and Will counties.

*Peter Hettinger pits near North Aurora*

Three-quarters of a mile south of North Aurora the terrace deposit is 4½ feet thick as exposed in the pit of Mr. Peter Hettinger. The thickness varies and probably no more than 10,000 tons are available. Sample No. 5 (Table 30) is representative of the average total section exposed in the pit. A few pebbles are present. Gravel lies at the surface of the adjacent east slope. Farther up the slope and on the rolling upland adjacent are sand deposits which have been worked in the past and which still contain some molding sand, although it is impossible to estimate the extent without detailed work.

*Daniels pit near Aurora*

South of Aurora, in the northwest angle between the Aurora, Plainfield and Joliet Electric Railroad and the Montgomery road, in sec. 4, T. 37 N., R. 8 E., is a pit which was formerly worked by Mr. John Daniels. The sand was dug by scrapers and dumped through a trap into cars. There are possibly 25,000 tons of molding sand available in the vicinity.

*Deposit near Lily Lake Station*

North of Lily Lake Station is a widespread layer which does not exceed 1½ feet in thickness. Sand is present in the roadcuts in secs. 5, 6, and 7, T. 40 N., R. 7 E., and in secs. 31 and 32, T. 41 N., R. 7 E. It is doubtful if this particular deposit is of commercial value but it is an indication that the area is favorable.

## Kendall County

The terraces and valley wall slopes of Fox River in Kendall County (fig. 43) comprise favorable areas for natural-bonded molding sand. There is some possibility of surface deposits of molding sand on the uplands, especially in localities underlain by gravel. The southwest half of the county is not favorable, and shipping points, except on the electric lines, are far distant.

*Deposits south of Plano*

The only evidences seen of workable deposits of natural-bonded molding sand were in sec. 34, T. 37 N., R. 6 E., 1¾ miles south of Plano. The ridges on both sides of the road are very sandy and in places the 2 or 3 feet just beneath the soil contain bond. Sample No. 19 (Table 30), taken on the east side of the road, is a composite of the heaviest exposure seen. The sand is of Type I and might well be utilized, even though the clay content of produced grades would necessarily be lower than that of Sample No. 19. It was reported that molding sand has been produced from this vicinity although the exact locations were not found. It is impossible to estimate the amount available as the bonded sand occurs in patches, the number and limits of which would have to be determined before development could take place.

A small patch of molding sand of the same type was seen at the branching of the road in sec. 4, T. 36 N., R. 6 E., 2 miles northwest of Millbrook.

### *Core sand near Millington and Plano*

Core sand is produced at the Ballou White Sand Company's pit near Millington in this SW.¼ sec. 19, T.36 N, R.6 E. The silica sand is pumped from the pit and washed. Much of their product is sand-blast sand which is graded by a pneumatic size separator. Core sand is also available from the sand layers which occur in gravel pits, as in the pit of the Plano Cement Products Co., in the northeast part of Plano.

## Lake County

No deposits of natural-bonded molding sand of sufficient extent to be commercially valuable were seen in Lake County. The valley and lower slopes of the valley walls of Fox River are likely to contain stream-terrace and slope-mouth deposits which are workable. The west half of the county may contain deposits of small extent but their value is doubtful. Due to the short distance to Chicago, a deposit of no more than 10,000 tons, located near a shipping point, might be developed profitably.

### *Core sand*

The dunes along the shore of Lake Michigan from Waukegan to the State Line are suitable for core sand and doubtless are being utilized locally. Extensive development is not probable in view of the large and more accessible deposits at the south end of Lake Michigan.

## La Salle County

### *Silica sand*

La Salle County (fig. 44) furnishes more than half the foundry sand produced in Illinois. The total production is obtained from a single formation, the St. Peter sandstone[1], which forms the bluffs and underlies the terrace of Illinois River valley for more than 10 miles west of Ottawa. It is also exposed in the valley of Fox River. Easily accessible to rail and water transportation, this sandstone has been extensively developed because of its purity and friability. Production may be divided into two classes, pit-run sands and washed sands.

### *Washed silica sand*

For the production of pure silica sand for the glass industry special washing and sizing equipment has been developed. Core sand represents only a small fraction of the output but, due to use of methods developed primarily for other products, the purity and sizing far excel that which would be possible were core sand the only product. The cost of such sand is necessarily relatively high.

### *Pit-run silica sands*

The production of pit-run sands is largely consumed by steel foundries, where it is used as the grain to which fire clay is added as bond. The

[1]Cady, G. H., Geology and mineral resources of the Hennepin and La Salle quadrangles: Ill. State Geol. Survey Bull. 37, 1919.

FIG. 44.—Map of La Salle County, showing area of silica-sand production.

refractoriness, uniformity of grain size, spherical shape of grain, and friability of the pit-run sand, make it a suitable sand for use in steel founding. The presence of iron-stained grains is of additional advantage as the bond strength is thus increased.

Pit-run sand is commonly used as core sand. It is said that some pit-run sand from near the top of the section contains ample bond for gray-iron molding. None of this bonded sand was seen in sufficient quantity or suitable location for production. Sample No. 126 (Table 30) is a silica sand as dug. The tests show it to be of no value as a greensand. It might be suitable for some work if used in dry sand molds. It should be of value as a core sand.

*Synthetic molding sand for low refractory use*

The question of synthetic molding sand is a recurrent one in the foundry industry. The St. Peter sand might well be used as the grain for a milled mixture of sand and clay. The difficulties of mixing are such that it is improbable that such a product could compete with the present production of natural bond sands.

*Generalized geologic section of the St. Peter*

As the geology and stratigraphy of the district are to be discussed in another publication[1] it is hardly necessary to go into them here. In general the thickness of the worked section of the St. Peter is recognized to consist of three general zones: (1) The deeper sands such as are worked below the terrace level. These are purer and coarser than the rest of the St. Peter. (2) A zone of finer friable sand distinguished by the presence of magnesium. (3) A harder zone, coarser in texture, iron-stained, and containing iron-stained grains near the top of the section.

The washed sands commonly come from the upper and the lower beds and the pit-run sands from sections containing varying proportions of (1), (2), and (3). The texture of (2) and (3) differs considerably; a mixture of the two is texturally less suitable for steel sand than is (3) alone, as the finer grains from (2) tend to close up the sand, making it less permeable.

*Production of pit-run silica sand*

The production between Utica and the concrete highway bridge is largely pit-run sand taken from quarry faces in the total available section. One company, The Higbee Canyon Sand Co., operates a quarry face in each zone. The Benson Brothers Sand Co., Ottawa Steel Molding Sand Co., Commonwealth Silica Co., Illinois Valley Silica Co., American Silica Sand Co., and Utica Fire Sand Co., are other companies which produce pit-run sand for steel and core work. All load directly into cars with wheelbarrow, steam shovel, or cable skip. The thickness of overburden, thickness of section, and manner of working are the factors which determine the price; for the quality, except for impurities due to carelessness of working, is much the same in all pits where the available face is worked as a unit.

[1]Currier, L. W., Geology and mineral resources of the Ottawa-Marseilles quadrangles. Manuscript in course of preparation.

The permeability of the steel sand would be greater if textural zones were worked as units, as there is much less textural variation within a zone than in a mixture of two zones. Such procedure is not economically possible in pits with a vertical face as the whole face must come down. Where slopes are more gentle, each zone may be worked as a separate pit.

Unless the most desirable sand lies on top, the uppermost stratum may have to be removed as well as the overburden. If the top stratum is desirable but thin, excessive overburden may not permit its development as a unit.

*Production of washed silica sand*

The plants which wash and grade the pit-run sands, pump from a sump in the pit. Foundry sands are only a small part of their total production. The Ottawa Silica Co., U. S. Silica Co., Crescent Silica Co., Bellrose Standard Silica Co., Wedron Silica Co., and E. J. Reynolds Silica Co. all operate washing and grading plants.

*Silica sand resources*

The resources of silica sand are very much larger than the resources of natural-bonded molding sand. At least 20 million tons are available for production in the Ottawa district. As development proceeds the most available parts of the deposit will be worked out and the increase in operating cost will allow only large-scale production.

*Natural-bonded molding sand resources*

Natural-bonded sand is not plentiful in La Salle County. The lower courses of the creeks tributary to Fox River are the most favorable areas. One such deposit in the SE.¼ SE.¼ sec. 4, T.34 N., R. 4E., a mile northeast of Wedron, was once worked. A 4-foot section with scant bond was seen at several points. As most of the grains are of silica sand and are to some degree coated with limonite, such a sand might be of some value for foundry mixing. Some silt is present in very thin layers and it is quite probable that the sand is Type III material.

## Lawrence County

The extensive terrace of Wabash River (fig. 49A) does not itself contain molding sand, but old dunes and slope mantles composed of windblown sand derived from the terrace sands and lying on the terrace, do include molding sand. Such deposits are not always topographically evident. Low swells on the flat terrace and west-facing slopes of hills are the most favorable locations in Lawrence County for the occurrence of molding sand. Isolated dunes commonly contain Type I sand, and slope mantles Type III sand.

*Terrace-dune deposit east of Lawrenceville*

A 3-foot section of molding sand is exposed in a cut of the Baltimore and Ohio Railroad, 1¼ miles east of Lawrenceville, in the NW.¼ SW.¼ sec. 3, T.3 N., R.11 W. Sample No. 195 (Table 30) is representative of the section. It is an excellent Type I sand. Between 30,000 and 120,000 tons. are available. The vicinity is favorable for other deposits.

*Slope-mantle deposit north of Lawrenceville*

A 3-foot section of molding sand was seen in a road out in the SW. ¼ SW. ¼ sec. 17, T. 4 N., R. 11 W. The deposit is a slope mantle and is probably small in extent. Such a sand is liable to considerable horizontal and vertical variation. The deposit is 2 miles from a shipping point.

## Lee County

In spite of the fact that Lee county is traversed from northeast to southwest by a belt of sand, it is not a favorable territory for molding sand. The greater part of the sand has been and is being shifted by the wind, a condition which makes the formation of natural-bonded molding sands impossible.

Any workable deposits found will of necessity be of very fine sand or silt as these allow the formation of a soil and the subsequent formation of bond.

Such a deposit was seen just north of the Chicago and Northwestern Railroad, on the line between sec. 24, T. 22 N., R. 11 E. and sec. 6, T. 39 N., R. 1 E., 3½ miles northeast of Ashton. A 2-foot thickness is present and apparently about 20,000 tons are available.

The terraces of Rock River are of gravel and the presence of molding sand is hardly to be expected.

## McHenry County

The only deposit of molding sand being worked in McHenry County (fig. 43) is located on the terrace on the east bank of Fox River. This is the northward extension of the Kane County deposit already described (see Kane County Report).

*Garden City Sand Co. pit near Algonquin*

The pit of the Garden City Sand Co. is on the property of Mr. H. F. Dierck, in the E. ½ SW. ¼ sec. 34, T. 43 N., R. 8 E., a mile south of the town of Algonquin. A 4-foot face, lying on coarse gravel, is worked, and the pit run constitutes the grade sold. Like the Kane County sands, this sand is Type III. Some lateral variation in bond is present but in the production of a grade, this is not a serious disadvantage. Sample No. 9 (fig. 35A and Table 30) was taken from a partly loaded car and represents the total section.

*Friend deposit near McHenry*

On the farm of Mr. S. H. Friend in the SE. ¼ NE. ¼ sec. 26, T. 45 N., R. 8 E., half a mile northeast of the town of McHenry, there is a deposit of sand covering at least two acres which, though not of the best quality, might be utilized if properly dug. The upper foot is very heavy and might be mixed with the sharp sand which lies below. Though not especially valuable in itself, this deposit is indicative that the terraces and slopes of the Fox River valley are well worth careful prospecting.

*Consumer's Gravel Co. property near Crystal Lake*

A molding sand deposit on the property of the Consumer's Gravel Co., near the center of sec. 16, T.43 N., R.8 E., 3 miles south of the town of North Crystal Lake, is not worked but the molding sand is discarded as part of the strippings on the east side of the gravel pit. There is considerable lateral and vertical variation of texture and bond. Sample No. 21 (Table 30) comes from several channels in the 3- to 4-foot section of sand exposed at the south end of the east wall of the pit, and Sample No. 22, from several channels north of the middle. Both are Type III sands and will be somewhat variable in fineness and bond strength. The deposit probably covers 20 acres east of the exposure, although there is likely to be much variation in texture and bond. Low, broad knolls on the flat plain which extends from north of Crystal Lake to the valley at Algonquin may contain molding sands.

*Western two-thirds of McHenry County*

No evidences of workable deposits were seen in the western two-thirds of McHenry County and their occurrence there is improbable.

## Madison County

The major part of the molding sand resources of Madison County is contained in the deposits mantling the bluffs of the Mississippi. The terraces on the valley flat have been worked, but the total amount of molding sand available from them is small.

All the molding sand now produced is of Type III, fine in texture, and suitable for small and medium castings. It is not probable that coarser molding sands will be found. The deposits which mantle the bluffs (fig. 22), being a combination of windblown sand and silt and rainwashed sand, silt, and clay, are coarser near the base of the bluff and finest at the crest. Other variations along the hillside are dependent upon the steepness and direction of the slope. As a pit face is worked up the hill or along the slope, the fineness changes very gradually. The production of many grades cannot be maintained, especially if the grade distinction is made on pit location rather than on texture.

Molding sand is no doubt present along the bluff, in many places accessible to transportation. The loess, or Type II sand, is present in abundance and caps the bluff for many miles (fig. 21).

Core sand is abundant and may be taken from the lower part of the dunes or from the deposits of sharp sand in the bluffs.

*Commercial Foundry Sand Co. pits near Collinsville*

The Commercial Foundry Sand Co. operates pits located on the bluff slope in the NW. ¼ SW. ¼ sec. 29, T. 3 N., R. 8 W., 1½ miles northwest of Collinsville. Several faces have been opened, all furnishing relatively fine molding sand. No. 175 is a sample of the coarsest sand present. The pits in the lower part of the slope contain a 3- to 6-foot thickness of sand with reduced bond, a part of this thickness being free from lime. Sample No.

172 (Table 30) is the leached portion, while No. 173 is unleached, containing lime carbonate. The textural range is small and the bond uniformly strong as considerable clay substance is present in addition to the silt. At least 20,000 tons are available on the property. Fine yellow silt or loess, containing lime, is present near the top of the slope. Its value as a molding sand is dependent upon local demand.

### *Friesen Molding Sand Co. pits near Collinsville*

Half a mile north of the pits of the Commercial Foundry Sand Co., the Friesen Molding Sand Co. has opened several pits in the sands which mantle the slope. As in the Commercial Foundry Sand Co. pits described above, the coarser sands lie near the base of the loess-capped slope. No large amounts of sand are available on this property.

### *Other deposits*

An abandoned pit was seen in the loess which caps the bluff just north of the Troy and Eastern Railroad in the SW.¼ sec. 26, T. 3 N., R. 8 W. Another abandoned pit lies just to the east in the creek flat. The exposed sand contains much humus and is not well sorted.

A large dune north of the mouth of the small valley which cuts the bluff at Peters may contain molding sand, although several auger borings showed only sharp sand.

Core sand is produced for the Ed. B. Squier Co. from a deposit just east of the station at East Alton. This formerly contained a 4-foot layer of molding sand which has been worked out on this property. The molding sand is no doubt continuous for some distance, but building development prohibits further working. Many auger borings in accessible locations on this terrace level showed only sharp sand to a depth of 6 feet. No workable thickness was found even below that depth. It seems probable that workable thicknesses of molding sand are present under the sharp sand but that they are very local in extent and that their discovery is largely a matter of chance. Hollows are the most favorable areas because a part of the sharp sand has been removed by wind.

## Marshall County

The most favorable areas for molding sand in Marshall County are the terraces of Illinois River and the slope of the east valley wall.

### *Peter Hank deposit near Henry*

Deposits along the east valley wall of the Illinois are, in general, fine in texture and of slight extent. Such a deposit was sampled (Sample No. 127, Table 30) on the property of Mr. Peter Hank, sec. 4, T. 30 N., R. 2 W., a mile east of Henry. The thickness of 10 feet was continuous over a quarter of an acre. Such small deposits, when thick and of good quality, should be well worth working. It is quite probable that other deposits are present at the base and on the slopes of the bluffs.

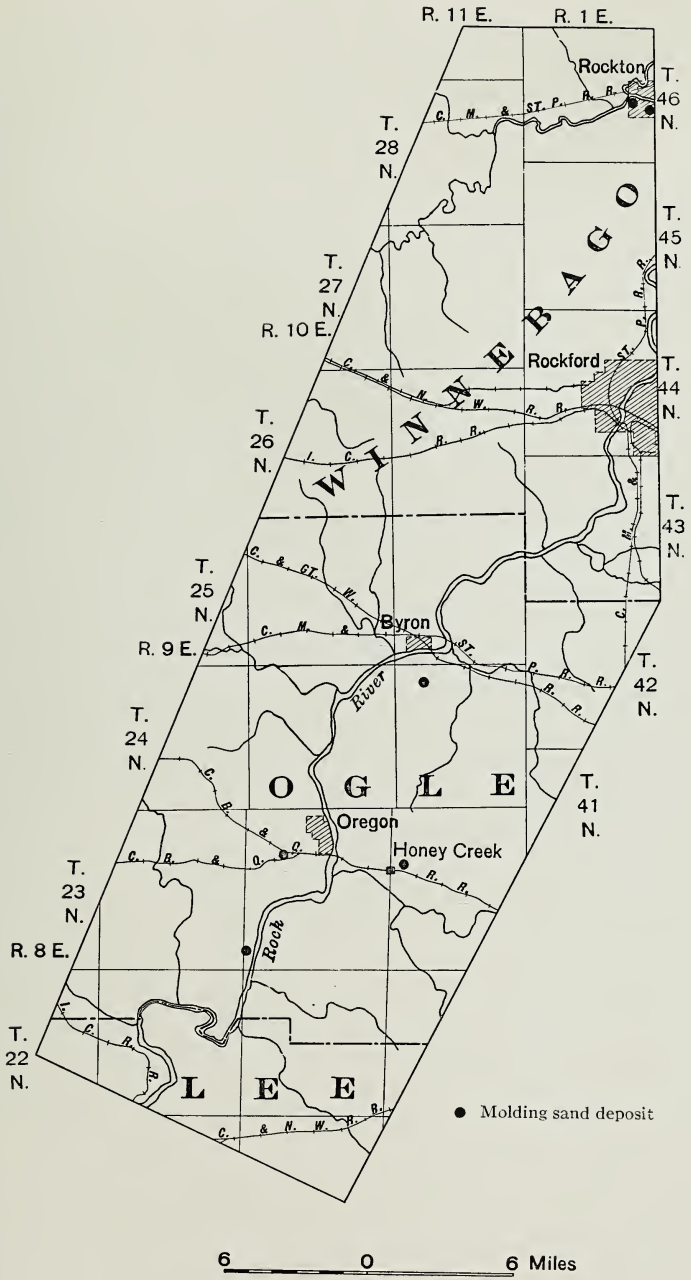



FIG. 45.—Map showing molding sand deposit of Ogle and Winnebago counties.

*Other deposits*

West of the river, 3½ miles southwest of Henry, there is exposed on the line between secs. 24 and 25, T. 13 N., R. 9 E., a very coarse-textured sand which is suitable for use, and could be profitably produced if obtainable in sufficient quantities. The thickness is exceedingly variable and the fineness varies within short distances. This is the type of sand to be expected on the higher ground of the terrace on the west side of the river. Its presence is sometimes revealed by low broad swells.

Prospecting of the areas near transportation might reveal deposits of the Buda-Wyanet type (See Bureau County report) on the uplands west of the river.

The eastern half of the county is not favorable for molding sand.

## Ogle County

The valley and bluffs of Rock River, the terraces near the mouth of Kyte River southeast of Oregon, and the sandy plain in the vicinity of Flagg Center are the only areas in Ogle County (fig. 45) favorable for natural-bonded molding sands. St. Peter silica sand outcrops in the vicinity of Oregon.

*Deposits near Byron*

At the south bluff of Rock River in the NE. ¼ NE. ¼ sec. 5, T. 24 N., R. 11 E., a mile east of Byron, 2 to 3 feet of an open Type I sand (Sample No. 54, Table 30) is exposed in a road cut. The sand does not have enough bond for use as greensand, but if mixed with a small amount of fire clay, it might prove of value. This locality is well worth careful prospecting for Type I sands. Half a mile west of Byron and at several points along the Blackhawk trail within 5 miles south of Byron, there are evidences of molding sand in the road cuts, but it is doubtful if any workable deposits are present.

*Deposit south of Oregon*

Five miles south of Oregon, in the W. ½ sec. 31, T. 23 N., R. 10 E., along the Blackhawk Trail, a knoll of sand some ten acres in extent contains a 3-foot thickness of sand (Sample No. 57, see fig. 29 and Table 30), overlain by 2 feet of sandy soil. In all physical properties it is an ideal Type I sand. It is for the most part derived from the white silica sand which outcrops near by and hence should be very refractory. The haul of five miles to Oregon, the nearest shipping point, is a serious drawback to development.

*Deposit near Honey Creek Station*

Adjacent to the Chicago, Burlington and Quincy right of way just northeast of Honey Creek Station, a deposit of sand lies on the terrace flat and extends up the slopes to the road which crosses the center of sec. 7, T.23 N., R.11 W. Sample No. 55 (Table 30) was taken from a 3-foot thickness discovered by the auger in the northwest corner of the SW. ¼ SW. ¼ sec. 7. The test shows a Type III sand. Uniformity could not be expected

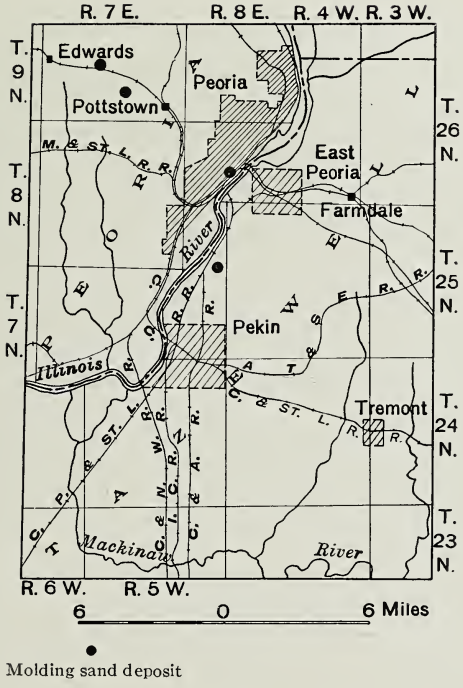



FIG. 46.—Map showing molding sand deposits of Peoria and Tazewell counties.

in this deposit. The deposits have an extent of 60,000 tons and possibly two or three times that amount.

*Deposits near Flagg Center*

The value of the sand at and south of Flagg Center is doubtful as the texture and bond are extremely variable. The best deposits of the area lie along the east spur road between secs. 16 and 21, T. 40 N., R. 1 E., half a mile south of Flagg Center. It is doubtful if a commercial pit could be developed, as the production of a uniform grade would be difficult.

*Silica sand*

The silica sand which outcrops around and south of Oregon has been developed by the National Silica Co., whose pit is located just south of the north branch of the Chicago, Burlington and Quincy Railroad, two miles southwest of Oregon. The product is washed and screened and the only foundry sand produced is core sand. Development of new shipping pits producing foundry sands from the silica sand is unlikely.

## Peoria County

Deposits in Peoria County (fig. 46) which may contain workable molding sand are of two widely variant kinds, each confined to a single general locality.

(1) Dunes on the surface of the gravelly terraces of the Illinois River valley, topographically evident as low knolls, may contain a coarse, heavy, Type I molding sand. The small extent of such a deposit would hardly permit extensive development. The wide valley flat south of Chillicothe is a favorable area.

*Worm pit near Peoria*

The only production at present from such a deposit is furnished from the pit of Mr. William Worm in the SW. ¼ NW. ¼ sec. 19, T. 8 N., R. 8 E., in the town of Peoria. A 2-foot thickness of coarse, heavy molding sand (Sample No. 154, Table 30), overlain by 2 feet of clay, lies upon the terrace deposits. The latter consist of coarse sand and fine gravel, which is produced as cement sand. The molding sand is hand-shoveled and trucked to local consumers.

It is not probable that deposits of this type are present in this county south of the mouth of Kickapoo Creek. The extensive stream terraces across Illinois River (see Tazewell County report) contain widespread deposits.

(2) Stream-terrace (Type III) sand deposits occur in the low hills which border the valley of Kickapoo Creek. Only a limited area, between Edwards and Pottstown, contains material which might be used for molding sand. East of Edwards, 2½ miles just northeast of the intersection of the Peoria road and the hill road, a slope exposes the following section:

| | *Thickness Feet* |
|---|---|
| Fine gravel, sharp sand, and clay | 0-5 |
| Fine bonded sand, calcareous | 10[1] |
| Yellow silt, calcareous | 5 |
| Fine bonded sand, leached | 10[2] |
| Peoria road level. | |

The layers do not contain bond for more than 200 yards along the face of the hill and it is impossible to predict the extent or bond content of the unexposed part of the deposit. Between 25,000 and 100,000 tons are available, overlain by thin soil.

The hill is so situated that each stratum could be worked separately by terracing. The tracks of the Chicago, Burlington and Quincy Railroad are about 100 yards distant.

Across Kickapoo Valley, a mile southwest of the above location, in the NW. ¼ SW. ¼ sec. 27, T. 9 N., R. 7 E., 2½ miles northwest of Pottstown, there are 10 to 15 feet of fine bonded sand, overlain by 1 to 5 feet of the clay which caps the hill. The sand is exposed in a few places in the timbered ravines and on the valley wall itself. Sample No. 153 (Table 30) is representative of the upper 8 feet of a 10-foot section. The sand is slightly calcareous and it is probable that the lime content will vary horizontally. At least 20 acres are underlain by the deposit but only extensive prospecting could determine the amount suitable for use as molding sand. The tracks of the Chicago, Burlington and Quincy Railroad are across the valley, three-quarters of a mile distant.

Molding sand may occur at other points along the valley walls of Kickapoo Creek. The occurrence of a lime-free sand is hardly to be expected in this type of deposit, especially if it be overlain by the yellow surface clay common in the region.

## Pope County

The molding sand deposits of Pope County (fig. 47) are confined to the lowlands in the vicinity of Homberg and Brownfield. This area was a river channel at some time, judging from the extensive deposits of sands and silts. Those deposited by water are fine in texture, and both Type II and Type III are represented. Windblown deposits in the form of dunes are present and, as is common with such deposits, they contain Type I sands.

### *Type II and Type III sand deposits*

The three samples taken of the fine sands can hardly be considered representative of the silty deposits as a whole, but typical of a small area only. In the NW. ¼ SE. ¼ sec. 2, T. 14 S., R. 5 E., a 3-foot section overlain by 6 inches of fine silt was sampled as follows:

No. 186 .....
- ½ foot fine silt
- 1 foot dark silt ..... No. 184
- 2 feet yellowish silt .... No. 185

Table 30 gives the results of the tests made on Samples No. 184, 185 and 186.

[1]Represented by Sample No. 150 (see Table 30 and fig. 33A).
[2]Represented by Sample No. 152 (see Table 30).

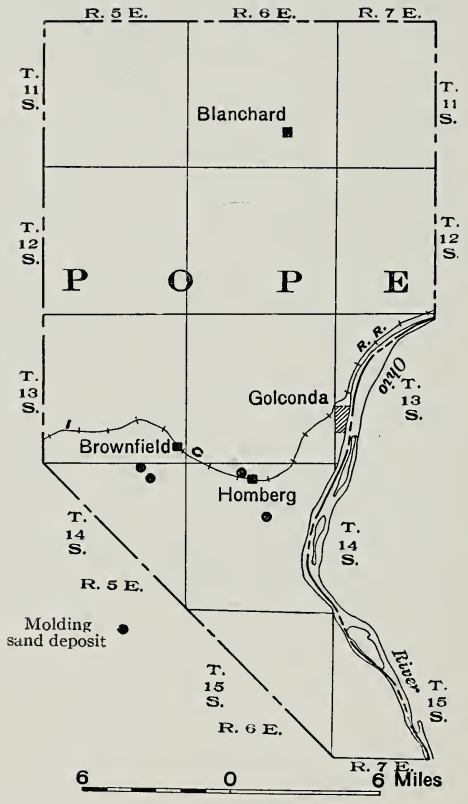



FIG. 47.—Map showing molding sand deposits of Pope County.

The possibility of the production of a uniform grade is small, considering the nature of the deposit. In the NE. ¼ NW. ¼ sec. 2, T. 14 S., R. 5 E., a 3-foot section was sampled (No. 189, Table 30). This is a true waterlaid Type II sand. Practically all of the clay percentage is fine silt. The low permeability makes such a sand of doubtful value. The whole deposit of fine sand and silts contains 180,000 to 1,200,000 tons and it lies between 1 and 2½ miles from the Brownfield station of the Illinois Central Railroad.

*Type I sand deposits*

Two samples of Type I sand were taken. Sample No. 187 is a very coarse sand occurring in a deposit containing about 5,000 tons in the NW.¼ NE.¼ sec. 15, T.14 S., R.6 E. Several similar deposits are in the vicinity. Sample No. 188 was taken in the NW.¼ SE.¼ sec. 4, T.14 S., R.6 E., adjacent to the Homberg siding of the Illinois Central Railroad. The deposit contains about 5,000 tons but several other old-dune deposits containing Type I sands are in the vicinity.

## Pulaski County

It is improbable that molding sand will be found in Pulaski County. A layer of red sand with iron-oxide bond exposed in the roadcut in the hill half a mile due south of Pulaski, was sampled (No. 183, Table 30), although at this place the deposit is not workable. This is the only kind of sand which can be expected and its value is doubtful.

## Randolph County

Randolph County is not a favorable area for molding sand.

*Clores Station deposit*

The only deposit seen occurs on a terrace of St. Mary's River, adjacent to Clores Station of the Wabash, Chester and Western Railroad, in the SW. ¼ NE. ¼ sec. 28, T. 7 S., R. 6 W. The deposit is alluvium and is exceedingly variable in texture. Sample No. 181 (Table 30) was taken from the upper 3 feet of the 7-foot thickness. Such a sand is of value only for local use. The extent of the deposit is 20,000 to 50,000 tons.

## Rock Island County

It would appear from the small amount of work done, that the foundries of the Quad-Cities are fortunate in having considerable available molding sand within and near Rock Island County (See Henry, Bureau, Henderson, and Hancock county reports). There are, undoubtedly, large deposits which are as yet untouched and will be developed only through systematic, careful prospecting and intelligent development. The utilization of vegetable-bond sands and the use of Type I sand in foundry mixes would fill all needs except for stove plate and for very heavy work. Cooperation between foundrymen and producers to the extent of giving local sands adequate tests is necessary.

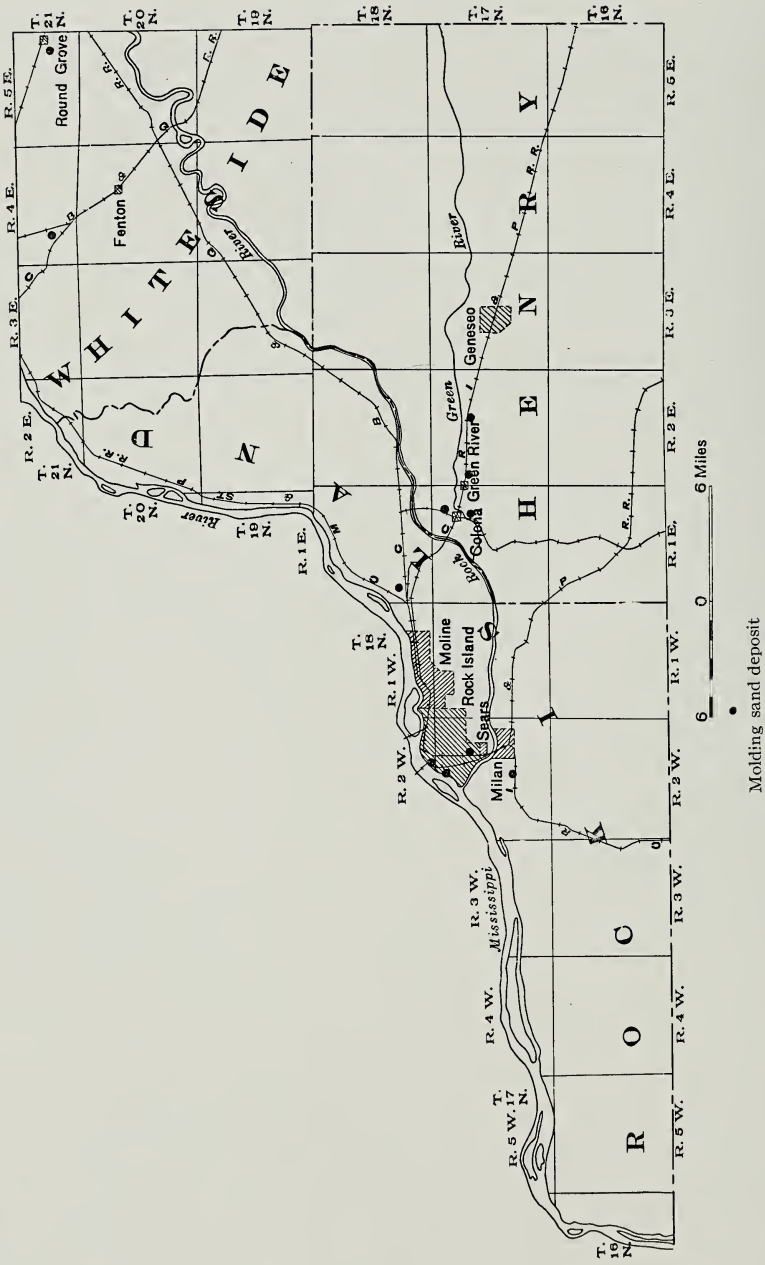



FIG. 48.—Map showing the molding sand deposits of Whiteside, Henry, and Rock Island counties.

The producing and prospective areas of Rock Island County (fig. 48) may be classified as follows:

1. Deposits on the terraces and flood plains of the Rock and Mississippi rivers.
2. Deposits on the uplands, especially those adjacent to the Mississippi and Rock rivers.

### TERRACE AND FLOOD-PLAIN DEPOSITS

The deposits on the flood plain of the Mississippi yield a black Type II sand which has a reduced-clay or so-called "vegetable" bond. Such sand may be economically used when obtained near by, but the short life of the bond prohibits development of shipping pits. In former times this kind of sand was widely used by the local foundries. As shown by the tests, the properties of these black Type II sands are not markedly different from Type III sands. The high silt content makes for a rather uniform bond strength throughout the working range and the permeability is very closely related to the silt percentage. When heated to 600° F., much of the volatile organic matter which is present in the clay grade is burned out, and when the sand is re-tempered this does not absorb moisture. The optimum moisture content is thus lowered, and as these sands normally decrease in bond strength with decreased moisture content, the bond strength is lowered. The vegetable matter is not in itself a binder but is a moisture absorbent which increases the efficiency of the silt bond.

The burning out of the vegetable matter does not appreciably increase the permeability as recorded by tests, as the specimen is rammed after the burning; but when in a mold the permeability of the rammed sand is no doubt much increased by the voids left by the burnt organic matter.

#### *Mud Island sand*

Sample No. 85 (Table 30) was obtained from a remnant of "Mud Island" sand in the bottom of a bin of the John Deere Harvester Works, East Moline.

#### *Blake pits, Rock Island*

Sample No. 105 (Table 30) was taken from the lower 3 feet of a 7-foot pit section on the property of the Blake Company, Rock Island, in the SW. ¼ NW. ¼ sec. 34, T. 18 N., R. 2 W. This sand has been used by that company for some time, and, although short-lived, proved satisfactory. The deposit is very nearly worked out on this property.

#### *Rock Island Molding Sand Company's pit near Pettifers Island*

Farther south, opposite the head of Pettifers Island, an area of about 200 acres is covered by at least a 2-foot layer of the black Type II "vegetable"-bond sand, some of which is worked by the Rock Island Molding Sand Co. Sample No. 78 (Table 30), from the SW. ¼ SW. ¼ sec. 3, T. 17 N., R. 2 W., is from a 2½-foot section of this company's pit. Sample No. 79 (Table 30) was taken in the NW. ¼ SW. ¼ sec. 3, T. 17 N., R. 2 W. and is a yellow sand which occurs in small isolated patches.

*Alluvium of lower Rock River valley*

A part of the area between Kickapoo Slough and the Illinois and Mississippi Canal might yield alluvial molding sand, particularly secs. 15 and 16, T. 17 N., R. 2 W.

*Rock River terrace deposits near Milan*

South of Kickapoo Slough, a 3-foot layer of coarse red molding sand is exposed in the creek bank in the southwest corner of sec. 22, T. 17 N., R. 2 W. Probably only a small quantity is available and its quality is questionable.

*Deposits east of Milan*

A 3½-foot thickness of fine yellow sand was sampled in the southwest corner of the SW. ¼ SE. ¼ sec. 22, T. 17 N., R. 2 W., two miles west of Milan (Sample No. 110, Table 30). This is a waterlaid Type II sand. It is not probable that this deposit contains more than 10,000 tons, but the nearness of a market and the adjacent railroad should stimulate prospecting in the vicinity.

*Terrace deposits near Silvis*

A terrace which yields Type I sand is found in the N. ½ SE. ¼ sec. 29, T. 18 N., R. 1 E., a mile northeast of Silvis. Some of this sand contains ample bond for use as molding sand, but the lateral distribution of bond is not sufficiently uniform for development except for local use. The Rock Island Molding Sand Co. produces some sand from this deposit. Sample No. 106 (Table 30) was taken from a 2-foot layer of the heaviest sand seen.

UPLAND DEPOSITS

The uplands, particularly the bluffs adjacent to the Mississippi and Rock River valleys are mantled with a thick layer of loess, the yellow silty material which is so evident in gullies and roadcuts. This calcareous Type II sand is utilized for molding sand and for core filler.

*Davis Molding Sand Co. pit near Sears*

The pit of the Davis Molding Sand Co., half a mile north of Sears, shows the twofold division into fine yellow and coarser grayish silts. Sample No. 102 (fig. 32A, Table 30), from Franks Foundries, Moline, is representative of the finest phase. Sample No. 84 (Table 30), from the John Deere Harvester Works, Moline, is the basal phase, and contains some coarser slope wash. It is a calcareous Type III sand. At least 16,000 tons of sand are available, but it is impossible to estimate the proportion of each kind.

*Other loess deposits*

There are numerous exposures of loess along the bluff in Rock Island, Moline, and East Moline, as well as farther up the river in the vicinity of Port Byron. There are also exposures along Rock River, and in the hills

north of Hillsdale located in sec. 20, T.19 N., R.3 E. The demand for this calcareous Type II sand is not great and deposits within town limits are sufficient to supply local demands.

## Sangamon County

The upland areas adjacent to Sangamon River contain deposits of sand and constitute the only favorable molding sand areas seen in Sangamon County. The sand is thickest at those points where the valley is directly to the west, and in some localities, as in E.½ sec. 11, T.16 N., R.5 W., the topography is suggestive of dunes.

The sand which underlies the surface soil in these areas is commonly sharp, but iron-stained layers and an occasional layer of bonded molding sand were seen.

### *Deposit near Spaulding*

A layer of molding sand 1 to 3 feet thick is exposed at the 570-foot contour level[1] in several places along the river road between Riverton and Spaulding. A 3-foot thickness made up of alternate bands of heavy and sharp sand is exposed in a roadcut in sec. 4, T. 16 N., R. 4 W., a quarter of a mile west of Spaulding.

An excellent Type I sand (Sample No. 156, Table 30), the heaviest sand seen in the county, was taken from this section. Much of the deposit is Type I sand which is lacking in bond strength, but as grains are coated with limonite, a foundry mix with a fire clay bond might make it a usable sand. It is probable that the deposit includes 10,000 tons, but the amount available is difficult of estimation because the quality may not be uniform and the overburden, which varies from 2 to 5 feet, may increase.

### *Deposit in E.½ sec. 11, T.16 N., R.5 W. near Streadle siding*

The upland area northwest of Streadle siding and 2 to 3 miles northeast of the State Fair Grounds contains a 2-to 6-foot layer of sharp, iron-stained, Type I sand under 2 to 5 feet of clay. A small amount of core sand is produced for local use. No workable natural-bonded sands were seen, but the iron-stained grains suggest that a mixture of the sand and fire clay might be of value. The overlying clay contains too much silt to be of value as a bond.

## St. Clair County

The bluff slopes are the only areas in St. Clair County favorable for the occurrence of molding sand, and only Type II and Type III sands are likely to be found there. Loess is very abundant.

### *O. J. Long pit, Caseyville*

A loess bank in the town of Caseyville is worked by Mr. O. J. Long, but very little of the production is for foundry use. Sample No. 180 (fig. 33 and Table 30), a typical loess, was taken from the lower 6 feet of the 18-foot pit section. Some 10,000 tons are available.

[1] See U. S. Geological Survey topographic map of the Springfield quadrangle.

## Tazewell County

The only favorable area for molding sand in Tazewell County (fig. 46) is the extensive terrace of Illinois River, lying between the flood plain and the valley wall.

### *Terrace deposit near Pekin*

A large deposit, probably in excess of 200,000 tons, occurs in secs. 13 and 24, T. 25 N., R. 5 W., 3¼ to 4 miles north of Pekin. Just south of the creek in the center of sec. 13, the road rises gradually onto a terrace about 30 feet high. Molding sand mantles the top of this terrace, the maximum thickness being 2½ feet. Sample No. 155 (Table 30) was taken from several channels in the total section exposed in a roadcut. The sample is very heavy, as only the layer containing bond was sampled. The deposit is capable of producing Type I sand and the high silt content of the sample taken is due to error in sampling, too much of the top material being included. It is certain that a more open sand would normally be produced from this deposit. Half a mile south, in sec. 24, T. 25 N., R. 5 W., the road again rises upon the terrace and molding sand is exposed in the road cut. The terrace level on which the molding sand is found is continuous to the valley wall, half a mile east. The whole area of the terrace is not covered by a uniform depth of sand but there is sufficient thickness over parts of the areas to make development worth while, as transportation is close and the Peoria market near by. No other workable deposits were noted, but the terrace area northeast, east, and southeast of Pekin is a possible one. South of Pekin, along and east of the Chicago, Peoria and St. Louis Railroad, there is abundant sharp sand, but no natural-bonded molding sand was found. The same is true along the lines of the Illinois Central Railroad and Chicago and Alton Railroad south of Pekin. As has been stated (Chapter III) it is seldom that natural-bonded molding sands are found in an area covered by sharp sand.

## Vermilion County

No deposits of commercially valuable molding sand were seen in Vermilion County. There are, however, several possible areas, as follows:

1. Little Vermilion River and its tributaries, particularly between Indianola and Georgetown. Patches of molding sand, generally with a thickness of 1 foot or less, are exposed here and there in the roadcuts at the top of the low valley walls. The terraces were not found to contain sand where auger borings were made.

2. Salt Fork and its tributaries. The terraces sometimes contain sand, patches of which contain bond. This type of sand is exposed at the point where the paved road crosses the creek, ¾ mile east of Muncie. It is not probable that extensive deposits will be found.

3. The sandy areas in the northern part of the county. It is improbable that molding sand deposits of commercial thickness and extent will be found. A typical exposure may be seen along the road in sec. 7, T. 22 N., R. 11 W., 2 miles east of Rossville. Only thin layers of poorly

bonded sand are exposed and the auger borings to a depth of 5 feet revealed only sharp sand.

## White County

The molding sand deposits of White County are all contained in old dunes on the terraces of Wabash River (fig. 49B). In former times there was much shifting sand, as evidenced by the low rounded knolls which are the present topographic expression of the dunes. The advance of vegetation and the consequent formation of soil on these dunes has caused the formation of Type I molding sand. Not all of the old dunes contain molding sand heavy enough for commercial use; hence, each knoll must be considered as a unit in prospecting.

### *Old dunes near Carmi*

The old dunes are especially numerous in the area northeast of Carmi. Sample No. 192 (fig. 30B and Table 30) was taken from several channels in a total 3½-foot section exposed in a roadcut in the SE. ¼ SW. ¼ sec. 8, T. 5 S., R. 10 E. The upper 1½ feet of the section is very heavy and the lower 2 feet relatively sharp but with limonite-coated grains. The knoll contains perhaps 42,000 tons and the fineness as exposed was very uniform.

### *Deposit near Simpson siding*

Sample No. 193 (Table 30) was taken from a 3½-foot section in the NW. ¼ SE. ¼ sec. 11, T. 5 S., R. 10 E., 3½ miles southeast of Simpson siding on the Big Four Railroad. From 40,000 to 100,000 tons are available in the deposit.

### *Deposit near Grayville*

Adjacent to the right of way and 1¼ miles south of Grayville, a 1- to 3-foot section of a finer Type I sand is exposed in a roadcut. The deposit appears to be a continuous mantle which thickens into low dunes. Sample No. 194 (Table 30) shows it to be an extraordinarily fine Type I sand. Between 20,000 and 240,000 tons are available.

It is certain that several deposits exist within a reasonable distance from transportation. The uniformity of the deposits and the good quality of the sand should more than offset the disadvantage of distance to markets.

## Whiteside County

In discussing the molding sand resources of Whiteside County (fig. 48), it is convenient to divide it into five units, as follows:

1. The Mississippi flood plains and terraces
2. The borders of the marshy channels connecting the valleys of the Mississippi and the Rock
3. The uplands northwest of Rock River
4. The Rock River terraces
5. The sand areas in the southeast part of the county

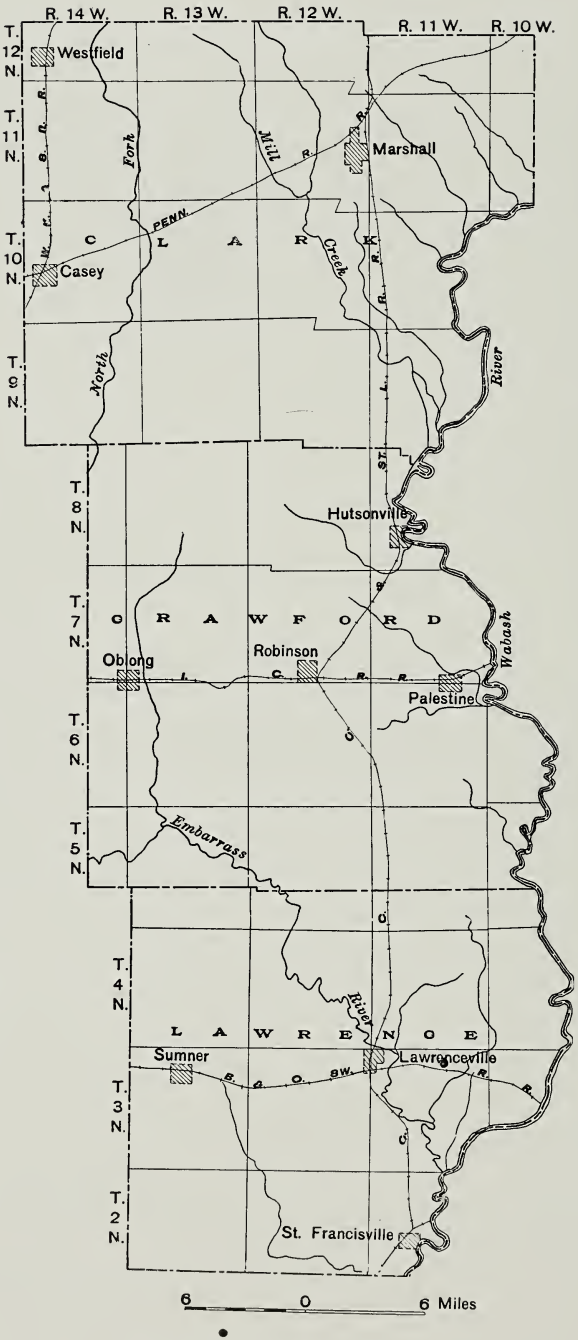



FIG. 49A.—Map showing the molding sand deposits on the Illinois side of Wabash Valley in Clark, Crawford, and Lawrence counties.

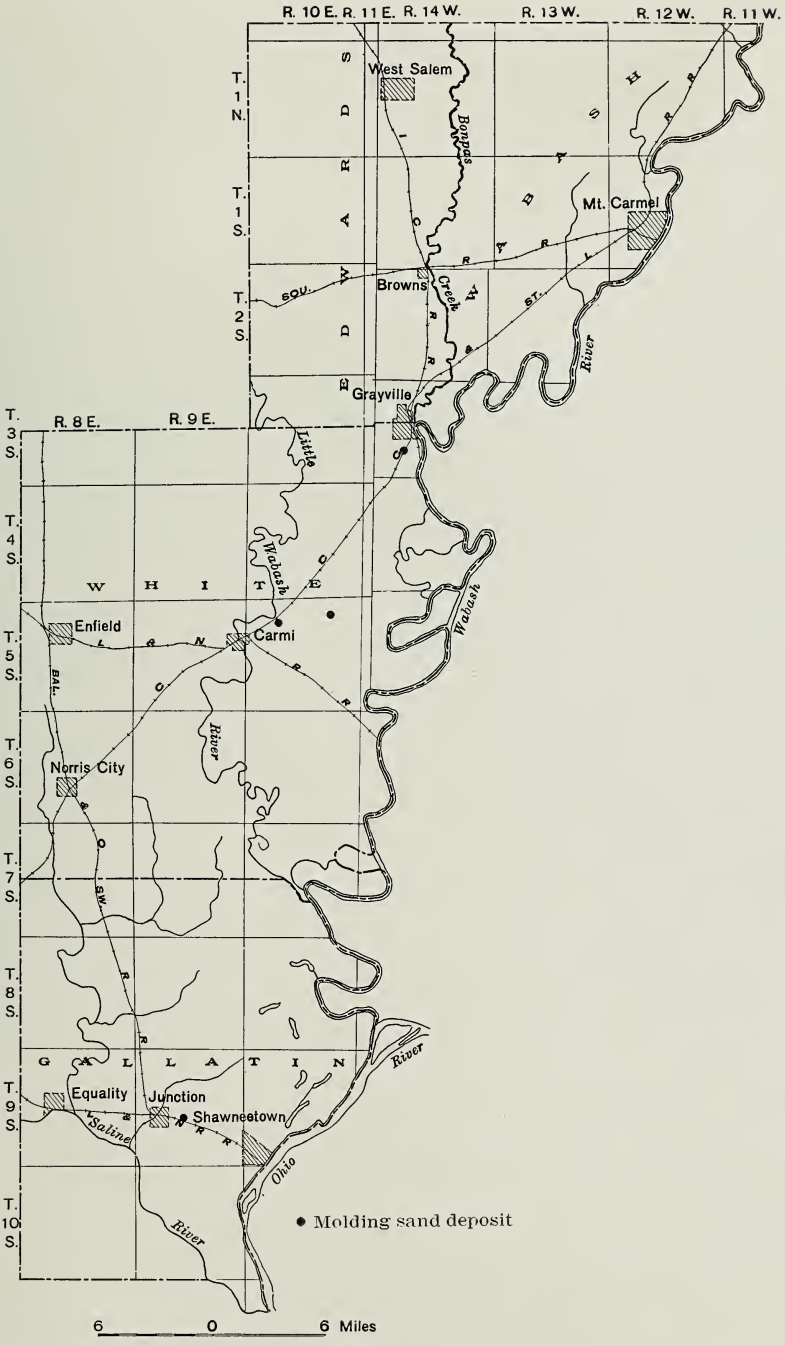



FIG. 49B.—Map showing the molding sand deposits on the Illinois side of Wabash Valley in Edward, Gallatin, Wabash, and White counties.

### MISSISSIPPI FLOOD PLAINS AND TERRACES

The flood plain proper is covered by alluvium and the only sand available would be black Type II or "vegetable"-bond sand which is valuable for local use only. Between the border of the flood plain and the bluff is a terrace, continuous with that of Carroll County, which extends from the north line of the county to the Chicago and Northwestern Railroad. Another patch extends from the south edge of Fulton to East Clinton. The area between lower Cattail Creek and the bluffs is also a terrace. The probability of the finding of molding sand and its mode of occurrence on these terraces is discussed in the Carroll County report.

### MARSHY CHANNELS CONNECTING MISSISSIPPI AND ROCK VALLEYS

The marshy character of the channels connecting the Mississippi and Rock valleys precludes the possibility of finding molding sand in them, but their terraces, as those of the Mississippi, are favorable areas. One such terrace area borders the upland in the southwestern part of Newton township (T.20 N., R.3 E.). It is similar in character to the terraces along the Mississippi, but because of its distance from a shipping point it is hardly worth prospecting. The borders of Cattail Valley are sandy, and on the property of Mr. Harry Hanzinga, in the NE.¼ NW.¼ sec. 32, T.21 N., R.4 E., 3 miles northwest of Fenton, a 2- to 3-foot layer of red Type III molding sand is exposed. The amount of bond is variable. Some parts of the deposit are underlain by sharp sand, but clay underlies the greater portion. Samples No. 68 and 69 (Table 30) are representative of this deposit, which appears to contain at least 50,000 tons. Both borders of Cattail Slough are worth prospecting as transportation is near by.

### THE UPLANDS NORTH AND WEST OF ROCK RIVER

Dune sand is present at many points along the Mississippi River bluff. It is valueless except for core sand for local use. The loess is very thick on the bluffs and mantles the surface of the upland and in many cases occurs in elevated ridges, as in the southwest part of Round Grove. There are two phases of this material, the lower a gray material containing brownish spots and seemingly coarser than the powdery yellow top layer. The top layer, except for about a foot just beneath the soil, is very calcareous.

#### *Garden City Sand Co. pit near Round Grove*

Just southwest of Round Grove in the pit of Mr. Clare Knox, operated for the Garden City Sand Co., a 12-foot thickness of loess is exposed. It is made up of 4 feet of the grayish lower layer (Sample No. 66, Table 30) which here grades into an upper layer 8 feet thick (Sample No. 65, Table 30). Both are calcareous Type III sands which approach Type II in properties. A large amount is available at this location and several thousand tons have been shipped by Mr. Knox.

In the vicinity of Morrison, in sec. 18, T.21 N., R.5 E. there are extensive deposits.

Within a radius of 1½ miles southwest of Fenton, there are probably more than 2,000,000 tons of loess.

### ROCK RIVER VALLEY

The terraces of the Rock contain fine gravel and in many places sharp sand is present, but molding sand was not seen. It is improbable that workable deposits will be found.

### SAND AREAS IN THE SOUTHEASTERN PART

The sand areas in the southeastern part of Whiteside County are a continuation of those in Lee County, and, as there, no molding sand is believed to be present.

## Will County

In general the western half of Will County (fig. 43) is the more favorable for the finding of molding sand, but there are no relatively large areas where molding sand is likely to be found. The deposits are all due to local conditions which affected a small area only. Hence the mention of only a few localities does not imply that others, not seen, do not exist.

### DEPOSITS NEAR RITCHEY

On the siding of the Elgin, Joliet and Eastern Railroad, half a mile south of Ritchey Station, located in sec. 18, T.32 N., R.10 E, three molding sand companies load their product. The area which has been developed is covered with 3 to 10 feet of windblown sand, beneath which is a layer of Type I molding sand of varying thickness. The sharp sand is shipped as core sand and is also mixed with the molding sand, which is a heavy grade. The core sands have been worked for some time but the development of the natural-bonded molding sands is comparatively recent.

#### *Riverside Sand Co. pits*

The pits of the Riverside Sand Co. are a few hundred yards northwest of Ritchey siding (Sample No. 12, Table 30). The grade is produced from a 3-foot section of silty Type III sand and is shipped for core work. Below this lies 4 to 6 feet of uniform-textured, heavy, Type I sand (Sample No. 15, Table 30). From 10,000 to 150,000 tons are available. An eighth of a mile north, a low ridge contains fine sands (Sample No. 13, Table 30), and although the texture varies, it is likely that a rather uniform grade of brass sand might be produced. Between 40,000 and 100,000 tons of molding sand are available on this property.

#### *Larson and Larson Sand Co. pits*

The pit of the Larson and Larson Sand Co. is about a third of a mile northwest of Ritchey siding. The molding sand is from 4 to 6 feet in thickness and is overlain by sharp sand. Sample No. 11 (Table 30) is a mixture of ⅔ heavy and ⅓ sharp sand. The heavy sand is Type I, and the sharp, Type III. At least 60,000 tons are available but there may be much more in the 22-acre tract.

### *G. A. Davidson Co. pits*

The pits of the G. A. Davidson Co., operated by Mr. Len Grundy, are within ½ mile southeast of Ritchey siding. Core sand only was being shipped but a layer of molding sand 4 to 6 feet thick lies beneath. Gravel is below at this point. At least 50,000 tons of molding sand are available.

It was reported that molding sand has been taken out near Custer Park just across the river from the Ritchey deposit. It seems quite probable that there is much more molding sand in the Ritchey deposit than is now evident. Much of it is Type I sand which is not produced as such. The Ritchey area is close to transportation and relatively close to the Chicago market, and should be developed on a larger scale.

## OTHER DEPOSITS

The discovery of other deposits similar to that at Ritchey would not be surprising. Although the areas of sharp sand which occur along Kankakee River do not ordinarily have a layer of molding sand below, they are worth prospecting if close to transportation. Areas close to the river and especially to the concave side of a bend are perhaps the most favorable.

### *Rockton Molding Sand Co. pit near Wilmington*

The Rockton Molding Sand Co. operates a deposit which is exposed in the roadcuts just east of the pipe line pumping station, three miles north of Wilmington. The exposed thickness does not exceed three feet. Sample No. 39 (Table 30) from the roadcut south of Prairie Creek and No. 40 (Table 30) taken north of the creek are illustrative of the uniformity of this excellent deposit of Type I sand. At least 8 acres are underlain by the 3-foot thickness.

It is possible that other deposits occur along the border of the flat. In sec. 24, T. 34 N., R. 9 E., 2 miles south of Millsdale, along the borders of the valley of Jackson Creek, there are evidences of sand but workable deposits were not found.

### *Des Plaines Valley deposits*

The valley of the Des Plaines is not as favorable for the accumulation of deposits of molding sand as are the valleys of creeks tributary to it. The extensive plains underlain by gravel may have a layer of molding sand just under the surface soil. Two miles east of Joliet, adjacent to the Michigan Central Railroad in the NE. ¼ NE. ¼ sec. 14, T. 35 N., R. 10 E., there is a small patch of molding sand. It is not of commercial value. Doubtless many small deposits of this type in the vicinity of Joliet have been worked for local use.

### *Du Page Valley deposits*

Only one deposit was seen along Du Page River but it is not improbable that others might be found. Near the center of the E. ½ sec. 27, T. 36 N., R. 9 E., 2½ miles south of Plainfield, several acres between the road and Isle la Cache Creek are underlain by a sand. Though the sand

is hardly suitable for use, the area and that to the northwest might, if prospected carefully, show deposits of sand of workable quality.

*Core sand*

Core sand is abundant in the Ritchey area and in general along Kankakee River.

*Fire clay*

Fire clay is shipped by the Illinois Molding Sand and Materials Co. from a pit in the hill in the SW. ¼ sec. 15, T. 35 N., R. 10 E. A 10-foot thickness of glacial till is worked with a steam shovel. The till is conveyed to the plant by narrow-gauge cars and is there mixed and ground.

## Winnebago County

The terraces, valley-wall slope, and immediately adjacent upland on the west side of Rock River contain the only molding sand seen in Winnebago County (fig. 45). The territory east of Rock River appears to be unfavorable. The terraces of Kishwaukee River consist almost entirely of gravel. The extensive sand flat of Pecatonica River near its mouth contains nothing but sharp sand. It is improbable that molding sand will be found on the uplands not adjacent to Rock River.

*Rockton Molding Sand Co. pits near Rockton*

The only producing molding sand pits are operated by the Rockton Molding Sand Co., whose milling plant is located on a siding of the Chicago, Milwaukee and St. Paul Railroad in the south edge of the town of Rockton. Sand is dumped from truck or narrow-gauge car into a hopper containing four 10-inch augers which break up lumps and mix the sand, whence it is fed slowly into a belt conveyor that elevates the sand to a cylinder mill. The mill consists of a fast- and a slow-running cylinder which disintegrate small lumps and feed the sand onto a conveyor belt which loads the cars. The patent for this cylinder mill is owned by the company.

Three-quarters of a mile west of the plant, on the south bank of the Rock, the same company operates a pit in the loess which mantles the slope. The material is uniform in texture, and the thickness varies up to a maximum of 15 feet. The extent of the deposit is difficult of estimate but it is certain that more than 18,000 tons are yet available. The sand is dug with a small steam shovel and hauled to the plant on a narrow-gauge tram. The uniformity of quality of the deposits and its thickness make such a method possible. Sample No. 50 (Table 30) is representative of this calcareous Type II sand.

The coarser grades are derived from the NW. ¼ sec. 25, T. 46 N., R. 1 E. The pits lie on the slope of the west valley wall of the Rock, which is mantled by windblown sand modified by slopewash and weathering. Sample No. 46 is an average sample of the more open sand which is hand-shoveled. This is used as one of the components of a mixed grade. Farther down the slope a very heavy Type III sand (Sample No. 49, Table 30) is dug by the machine pictured in figures 25, 26 and 27.

This machine may be set to any desired depth and takes off a constant thickness, delivering it to a truck. The open sand and the heavy sand are mixed in measured proportions, a wide range of bond grades being possible. Each truck load, a mixture of the desired proportions, is milled as described above and a thorough mixture is the result. Care is exercised in making certain that the quality of each part of the mixture is the same, and the accurate measurement and record of the proportions of the mixture is made in order to facilitate the reproduction of grades. On the flat hilltop west of the pits is a considerable deposit of a finer sand which is 3 to 5 feet thick over at least 10 acres and possible over as much as 30 acres (Sample No. 47, Table 30). This deposit had not yet been worked in July, 1923, but was soon to be developed. Sample No. 48 is from an abandoned pit face some 100 yards from the site of Sample No. 46.

### *Deposits near Roscoe*

Adjacent to the Chicago, Milwaukee and St. Paul Railroad, 1¾ miles west of Roscoe, a thin layer of molding sand was disclosed by the auger. A mile south of this point, in the SW. ¼ SE. ¼ sec. 6, T. 45 N., R. 2 E., a 2-foot thickness is exposed in the bank of the stream. It was assumed that the deposit is continuous along the railroad between the two exposures but it was not found to extend over the flat to the east. The deposit is thin, contains pebbles, and is probably patchy. It is hardly a commercial proposition. A thin layer was seen in a house excavation west of the Rockford road, in the NW. ¼ sec. 11, T. 44 N., R. 1 E.

### *Core sand*

There is an abundance of core sand on the flat of Pecatonica River and along the west valley wall of Rock River north of Rockton. Several producing pits, for the most part sporadically worked wagon pits, are scattered over sec. 1, T. 46 N., R. 1 E. The pit of Mr. George Putthennery, located just west of the road, in the south part of sec. 6, T. 46 N., R. 2 E., is a windblown deposit of even-grained sharp sand. The sand is put into a loading hopper with a cable skip and hauled by truck to Beloit, Wisconsin. Core sand is no doubt obtained in small quantities from the bars of Rock River or from small deposits of sharp sand which occur along the west side of the valley in the vicinity of Rockford.

## Location and Summary Description of Tested Samples of Molding Sand Deposits[1]

### ADAMS COUNTY

*Sample No. 139:* NE. ¼ NW. ¼ sec. 26, T. 1 S., R. 9 W. One-fourth mile north of Chicago, Burlington and Quincy siding. Sample taken from bin of Electric Wheel Company, Quincy, Illinois. From producing pit worked by J. A. Platt, Quincy, Illinois. Used for light gray iron and for bond renewal. Three- to seven-foot section. Extent,

[1]For descriptions, by counties, of the possible and already developed molding sand deposits, see the preceding pages.

20,000 to 100,000 tons. Formation, windblown silt or loess, capping east valley wall of Mississippi River. A calcareous sand containing primarily deposited bond.

BOND COUNTY

*Sample No. 52:* Location same as No. 171. Sample taken from bin of Greenlee Brothers, Rockford, Illinois. Used for heavy castings.

*Sample No. 53:* Location same as No. 171. Sample taken from bin of Greenlee Brothers, Rockford, Illinois. A finer grade than No. 52. Used for medium heavy castings. Mixes made of No. 52 and No. 53 to suit grade of work.

*Sample No. 100:* Location same as No. 168. Sample taken from bin of Frank Foundries, Moline, Illinois. Used for very heavy castings. Trade name, Greenville Coarse.

*Sample No. 166:* NW. ¼ NE. ¼ sec. 25, T. 4 N., R. 2 W. One and one-half miles east of Tamalco siding, Chicago, Burlington and Quincy Railroad. Worked by G. Nicol and Son, Collinsville, Illinois. Production for heavy gray iron work. Sample mixed in pit. Half and half mixture of heavy top sand and sharp basal sand. Extent, 100,000 to 280,000 tons. Formation, Illinoian fluvio-glacial sands containing weathered bond.

*Sample No. 167:* Location same as No. 166. Sample of produced grade from 7-foot pit section. Shipped for heavy gray iron work.

*Sample No. 168:* SW. ¼ NE. ¼ sec. 1, T. 5 N., R. 2 W. One and one-half miles south of Mulberry Grove siding of Vandalia Railroad. Worked by Warren Sand Company, Mulberry Grove, Illinois. Production for heavy gray iron work. Sample taken from two partially loaded cars. Pit section 7 to 9 feet. Extent, 100,000 to 200,000 tons. Formation, Illinoian fluvio-glacial sands containing weathered bond.

*Sample No. 170:* E. ½ SW. ¼ sec. 10, T. 5 N., R. 3 W. One-half mile northwest of Greenville siding of Vandalia Railroad. Worked by W. M. Peterson and Sons, Greenville, Illinois. Production for heavy gray iron work. Pit section 3 to 8 feet. Sample of produced grade taken from partially loaded cars. Extent, 120,000 to 200,000 tons. Formation, Illinoian fluvio-glacial sands containing weathered bond.

*Sample No. 171:* S. ½ SW. ¼ sec. 2, T. 5 N., R. 3 W. One and one-fourth miles north of Greenville siding of Vandalia Railroad. Worked by Ed. B. Squier Company, Federal Reserve Bank Building, St. Louis, Missouri. Production for heavy gray iron work. Sample from several channels in total 7-foot pit section. Extent, 100,000 to 300,000 tons. Formation, Illinoian fluvio-glacial sand containing weathered bond.

*Sample No. 179:* Location same as No. 166. Sample taken from bin of Enterprise Foundry Company, Belleville, Illinois. Used for heavy gray iron work.

BOONE COUNTY

*Sample No. 43:* NE. ¼ sec. 27, T. 45 N., R. 4 E. Three miles south of Capron Station of Chicago and Northwestern Railroad. Unworked deposit. Owner's name unknown. Sample from several channels in total

3-foot section exposed in creek bank. Extent, 20,000 to 40,000 tons. Locality favorable for similar deposits. Formation, stream terrace deposit. Sand contains weathered bond.

BUREAU COUNTY

*Sample No. 113:* SW. ¼ sec. 21, T. 16 N., R. 8 E. One mile southeast of Wyanet sidings of the Chicago, Rock Island and Pacific and the Chicago, Burlington and Quincy railroads. Worked by Golden and Larson, Wyanet, Illinois. Sample from several channels of 3- to 4-foot pit section. Same as produced grade. Used for light and medium gray iron work. Extent of deposit, 160,000 to 400,000 tons. Formation, windblown sand containing weathered bond. Mantled by 1½ feet of leached silty clay, a part of which is added to increase bond. Produced sand a combination of weathered bond and primary bond sand.

*Sample No. 114:* NE. ¼ NE. ¼ sec. 32, T. 16 N., R. 7 E. One and one-half miles northwest of Buda siding of Chicago, Burlington and Quincy Railroad and one-fourth mile west of Chicago and Northwestern Railroad. Producing pit worked by Mr. Lay, Buda, Illinois. Sample taken from several channels of 3½-foot pit section. Similar to produced grade. Sand used for light and medium gray iron work. Extent, 40,000 to 200,000 tons. Formation, windblown sand containing weathered bond. Capped by one-foot layer of silty clay. Very little top clay added to this sample.

*Sample No. 115:* Location same as No. 114. Sample taken from loaded car. A heavier grade than No. 114, produced from same weathered bond sand in addition to the silty clay capping.

*Sample No. 116:* NW. ¼ sec. 35, T. 16 N., R. 7 E. One mile east of Buda siding of Chicago, Burlington and Quincy Railroad. Worked by Jesse Westervilt, Buda, Illinois. Sample of produced grade, taken from several channels in 3-foot pit section. Used for medium gray iron work. Extent, 60,000 to 90,000 tons. Formation, windblown sand containing weathered bond. Capped by one foot of leached silty clay. Practically no clay added to sample. Heavier grades may be produced by addition of silty clay.

*Sample No. 117:* Location same as No. 116. Sample taken from single hole dug into upper two feet of 3½-foot section 200 yards from pit face. Similar in texture to No. 116.

CASS COUNTY

*Sample No. 138:* Location same as No. 143. Sample taken from bin of Electric Wheel Company, Quincy, Illinois. Used for medium gray iron.

*Sample No. 143:* Sec. 20, T. 17 N., R. 11 W. One-half mile to Arenzville siding of Chicago, Burlington and Quincy Railroad. Worked by G. Nicol and Son, Collinsville, Illinois. Sample from several channels in coarsest phase. A possible grade. Extent of entire deposit 50,000 to 120,000 tons. Formation, windblown sand containing weathered bond. Mantles lower portion of slope of east valley wall of Illinois River. Some

parts of section contain finer and coarser material interbedded and hence some produced sands are combinations of weathered bond and primary bond sands. The primarily bonded fine sands and silts which occur high on the slope are calcareous.

*Sample No. 144:* Location same as No. 143. Sample taken from several channels of finest producible sand seen in this pit. Sold for light gray iron and stove plate.

*Sample No. 145:* Location same as No. 143. A different pit face with a 5½-foot section. Upper 4 feet lime-free; lower 1½ feet contain lime concretions. Whole pit face worked for produced grade. Sample taken from several channels in upper 4 feet of section.

*Sample No. 146:* Location same as No. 143. Sample from lower 1½ feet of pit section noted under No. 145 is very calcareous and of no value for molding sand. This part of section should be kept out of produced grades.

*Sample No. 147:* NE. ¼ NW. ¼ sec. 27, T. 18 N., R. 11 W. One-eighth mile east of Bluff Springs siding of Chicago, Burlington and Quincy Railroad. Unworked deposit. Owner's name not known. Sample taken from several channels in 2- to 4-foot section exposed in roadcut. Extent 14,000 to 35,000 tons. Origin of sand same as deposit listed under No. 143. Finer textural phases shown. Sample is mixture of some weathered bond sand with much primary bond sand. Such a mix gives low permeability.

*Sample No. 177:* Location same as No. 143. Sample taken from bin of Eagle Foundry Company, Belleville, Illinois. Used for stove plate.

CLINTON COUNTY

*Sample No. 197:* No data on location. Sample sent in by Erne H. Duckman, Keyesport, Illinois.

COOK COUNTY

*Sample No. 10:* NE. ¼ SW. ¼ sec. 9, T. 42 N., R. 9 E. Five miles southwest of Barrington. Unworked deposit. Owner, Henry Louis. Sample taken from several channels of total 3-foot section. Overlain by 3 to 4 feet of sharp sand. Extent, 12,000 to 20,000 tons. Locality favorable for similar deposits. Formation, windblown sand, capping hilltop. Contains weathered bond.

FAYETTE COUNTY

*Sample No. 37:* Location same as No. 164. Sand from same part of deposit as No. 164. Sample taken from bins of National Malleable Company, Chicago, Illinois. Used for heavy castings.

*Sample No. 161:* SW. ¼ NW. ¼ sec. 32, T. 7 N., R. 1 E. Adjacent to siding on spur of Illinois Central Railroad. Unworked deposit. State Prison Farm, Vandalia, Illinois. Sample from single channel of total 9-foot section. Extent, 50,000 to 200,000 tons. Formation, Illinoian fluvio-glacial sands containing weathered bond.

*Sample No. 162:* Location same as No. 161. Sample from several channels in upper 5 feet of total 9-foot section.

*Sample No. 163:* SW. ¼ SW. ¼ sec. 32, T. 7 N., R. 1 E. One-eighth mile from siding of Illinois Central Railroad. Worked by P. and H. McKinney Company, Vandalia, Illinois. Sample is pit run from 15-foot section. Extent, 240,000 to 600,000 tons. Sand used for heavy gray iron work. Formation, Illinoian fluvio-glacial sands containing weathered bond.

*Sample No. 164:* SE. ¼ NE. ¼ sec. 14, T. 6 N., R. 1 E. One-half mile southwest of Bluff City siding of Vandalia Railroad. Worked by Eugene Stultz, Mulberry Grove, Illinois. Produced for medium gray iron work. Sample from several channels in 3-foot section. Extent, 20,000 to 100,000 tons. Formation, windblown sand capping east valley wall of Kaskaskia River. Contains weathered bond.

*Sample No. 165:* Location same as No. 164. Produced for heavy gray iron work. Sample taken from several channels in lower 5 feet of 9-foot section. Upper 4 feet extremely heavy sand. Extent, 80,000 to 380,000 tons. Formation, Illinoian fluvio-glacial sands containing weathered bond. Exposed in bluff at lower elevation than deposit from which No. 164 was taken.

*Sample No. 169:* SW. ¼ NE. ¼ sec. 32, T. 6 N., R. 1 W. Two miles east of Mulberry Grove, one-half mile east of siding on Vandalia Railroad. Worked by Coarse Red Molding Sand Company, Mulberry Grove, Illinois. Sample of produced grade, taken from partially loaded cars. Production for heavy gray iron work. Pit section 7 to 10 feet. Extent, 52,000 to 100,000 tons. Formation, Illinoian fluvio-glacial sands containing weathered bond.

### GALLATIN COUNTY

*Sample No. 190:* S. ½ sec. 21, T. 9 S., R. 9 E. One mile east of Junction sidings of Louisville and Nashville and Baltimore and Ohio railroads. Unworked deposit. Owner's name unknown. Sample taken from several channels in upper 2 feet of total 6-foot section, exposed in roadcut. Extent of this grade, 40,000 to 200,000 tons. Locality favorable for other deposits. Formation, windblown sands mantling west slope of Shawneetown Hills. Sands contain weathered bond.

*Sample No. 191:* Location same as No. 190. Sample taken from lower 4 feet of total 6-foot section. Directly underlies No. 190. Extent of this grade, 80,000 to 500,000 tons.

### HANCOCK COUNTY

*Sample No. 137:* W. ½ NE. ¼ sec. 2, T. 7 N., R. 7 W. One-eighth mile east of Dallas City siding of Santa Fe Railroad. Worked by Purity Molding Sand Company, Dallas City, Illinois. Sample taken from partially loaded car. Grade "No. 2." Extent, 12,000 to 20,000 tons. Formation, windblown sands and silt on slope of east valley wall of Mississippi River.

*Sample No. 149:* Same location as No. 137. Sample taken from bin of Brass Foundry Company, 711 S. Adams St., Peoria, Illinois. Used for brass work.

HENDERSON COUNTY

*Sample No. 86:* Location same as No. 133. Sample taken from bin of Marseilles plant, East Moline, Illinois. Used for medium gray iron work.

*Sample No. 101:* Location same as No. 133. Sample taken from bin of Frank Foundries, Moline, Illinois. Used for medium gray iron work.

*Sample No. 128:* NW. ¼ NE. ¼ sec. 15, T. 10 N., R. 5 W. One-fourth mile east of Gladstone siding of Chicago, Burlington and Quincy Railroad. Worked by W. H. Graham. Total pit section 16 feet. Sample taken from lower 5 feet of section. Slightly calcareous. Extent, 16,000 to 50,000 tons. Formation, windblown silt capping east valley wall of Mississippi River. Contains primarily deposited bond.

*Sample No. 130:* W. ½ SE. ¼ sec. 16, T. 10 N., R. 5 W. One mile south of Gladstone siding of Chicago, Burlington and Quincy Railroad. Worked by J. T. Galbraith. Sample from partially loaded car. Section 3 to 5 feet worked. Used for gray iron and brass. Extent, 24,000 to 50,000 tons. Formation, slope wash deposited at base of east valley wall of Mississippi River.

*Sample No. 131:* E. ½ sec. 11, T. 10 N., R. 5 W. On siding of spur of Chicago, Burlington and Quincy railroad. Worked by Monmouth Stone Company. Sample taken from several channels in total 4-foot pit section. Extent, 5,000 to 15,000 tons. Formation, windblown sands and silts on hilltops adjacent to Mississippi Valley.

*Sample No. 132:* NW. ¼ SE. ¼ sec. 20, T. 10 N., R. 5 W. Two miles southwest of Gladstone siding of Chicago, Burlington and Quincy Railroad. Unworked deposit. Owner's name unknown. Sample taken from several channels in 2- to 3-foot section. Extent, 3,000 to 8,000 tons. Locality favorable for similar deposits. Formation, windblown sand in dune on valley flat of Mississippi River. Contains weathered bond.

*Sample No. 133:* S. ½ NW. ¼ sec. 31, T. 8 N., R. 6 W. Two and one-half miles east of Dallas City siding of Santa Fe Railroad. Worked by Purity Molding Sand Company, Dallas City, Illinois. Sample from 2½-foot pit section used to produce grade "No. 2 open." Extent of whole deposit, 30,000 to 80,000 tons. Formation, windblown sands and silts on slope of east valley wall of Mississippi River. Sample is combination of weathered bond and primary bond sands interbedded in the section.

*Sample No. 134:* Location same as No. 133. Sample taken from 2-foot pit section used to produce grade "No. 1 open." Formation, same as No. 133. A less silty section.

*Sample No. 142:* Location same as No. 131. Sample taken from bin of Gem City Stove Company, Quincy, Illinois. Has been used for stove plate.

*Sample No. 176:* Location same as No. 133. Sample taken from bin of Eagle Foundry Company, Belleville, Illinois. Used for stove plate.

HENRY COUNTY

*Sample No. 76:* SW. ¼ sec. 2, T. 17 N., R. 1 E. One-half mile north of Colona siding of Chicago, Rock Island and Pacific Railroad.

Worked by C. E. Oberlaender and Company. Sample taken from several channels in 1- to 3-foot pit section. Coarser phase. Extent of deposit, 12,000 to 20,000 tons. Formation, windblown sands and silts capping top of valley wall of Green River. Deposit exceedingly variable in texture. All sands produced are combinations of weathered and primary bond sands.

*Sample No. 77:* Location same as No. 76. Sample taken from single hole dug in upper 2½ feet of 4-foot section.

*Sample No. 83:* Location same as No. 76. Sample taken from bin of John Deere Harvester Works, East Moline, Illinois. Used for medium gray iron work.

*Sample No. 88:* Location same as No. 76. Sample taken from bin of Union Malleable Company, East Moline, Illinois. Sold as "No. 5."

*Sample No. 93:* SW. ¼ SW. ¼ sec. 11, T. 17 N., R. 2 E. One-half mile south of Colona. Unworked deposit. Owner's name not known. Total 4-foot section; 1 foot coarse sharp, 1 foot fine heavy, and 2 feet coarse with medium bond. Sample 40 per cent sharp basal sand and 60 per cent heavy top sand. Total extent, 18,000 to 30,000 tons. Formation, windblown sand on valley flat of Green River. Contains weathered bond.

*Sample No. 94:* Same location as No. 93. Same section. Sample from heavy layer only.

*Sample No. 95:* Same location as No. 93. Same section. Sample from several channels in total 4-foot section.

*Sample No. 99:* Location same as No. 76. Sample taken from bin of Moline Plow Company, Moline, Illinois. Sold as "No. 6." Used for medium gray iron work.

*Sample No. 111:* SW. ¼ sec. 10, T. 17 N., R. 2 E. Three miles east of Green River siding of Chicago, Rock Island and Pacific Railroad. Adjacent to tracks of Chicago, Rock Island and Pacific Railroad. Unworked deposit. Owner's name unknown. Sample taken from several channels of 3-foot section exposed in roadcut. Extent, 30,000 to 240,000 tons. Locality favorable for similar deposits. Formation, low terrace deposit in valley of Green River. A waterlaid sand containing primarily deposited sand.

*Sample No. 112:* SE. ¼ SW. ¼ sec. 7, T. 17 N., R. 2 E. Three-fourths of a mile southeast of Green River siding of Chicago, Rock Island and Pacific Railroad. Abandoned pit. Mr. H. Stevens, owner. Sample taken from several channels in total 2- to 4-foot section. Extent, 40,000 to 100,000 tons. Formation, windblown sand on upper terrace of Green River. Contains weathered bond.

### JACKSON COUNTY

*Sample No. 182:* SW. ¼ NE. ¼ sec. 16, T. 9 S., R. 3 W. Adjacent to Sand Ridge siding of Illinois Central Railroad. Unworked deposit. Owner's name unknown. Sample from total 6-foot section. Extent, 60,000 to 480,000 tons. Formation, terrace sand on terrace between Big Muddy and Mississippi rivers. Contains weathered bond but also has

some layers containing primary bond. Appears remarkably uniform for such a large waterlaid deposit.

JO DAVIESS COUNTY

*Sample No. 61:* SW. ¼ NW. ¼ sec. 9, T. 27 N., R. 1 E. One-eighth mile west of Aiken siding of Chicago Great Western Railroad. Worked by Frank Einsweiler and Sons, Galena, Illinois. Sample taken from several channels in total 3-foot pit section of finer phase. Extent of deposit, 24,000 to 40,000 tons. Formation, terrace sands of Mississippi River.

*Sample No. 62:* Location same as No. 61. Sample taken from several channels in total 2-foot pit section of coarser phase.

*Sample No. 63:* NW. ¼ NW. ¼ sec. 22, T. 27 N., R. 1 E. One mile southwest of Rice Station of Chicago Great Western Railroad. Unworked deposit. Owner's name unknown. Sample from single channel in 12-foot section. Extent, 200,000 to 1,000,000 tons. Formation, windblown, calcareous silt or loess capping hilltops. Contains primarily deposited bond.

KANE COUNTY

*Sample No. 2:* SE. ¼ NW. ¼ sec. 1, T. 40 N., R. 8 E. Adjacent to spur of Chicago and Northwestern Railroad. Worked by J. G. Van Wicklin. Sample taken from partially loaded car. Pit section 3 to 5 feet. Extent, 40,000 to 80,000 tons. Formation, windblown sands which mantle slope of east valley wall of Fox River.

*Sample No. 5:* NE. ¼ SW. ¼ sec. 3, T. 38 N., R. 8 E. One-fourth mile to North Aurora siding of Chicago and Northwestern Railroad. Worked by Peter Hettinger, North Aurora. Sample taken from several channels in total 4½-foot pit section. Extent, 5,000 to 20,000 tons. Formation, windblown sand on slope of east valley wall of Fox River.

*Sample No. 6:* NE. ¼ SE. ¼ sec. 33, T. 39 N., R. 8 E. One-third mile north of the Sperry Company foundry, North Aurora. Worked by Sperry Company for foundry use. Medium gray iron work. Sample taken from foundry bin. Pit section 2 to 3 feet. Extent, 5,000 to 10,000 tons. Formation, windblown sand on terrace of Fox River.

*Sample No. 7:* SW. ¼ NE. ¼ sec. 16, T. 42 N., R. 8 E. One mile west of Carpentersville siding of Chicago and Northwestern Railroad. Worked by Frank Vogel. Sample taken from partially loaded car. One- to four-foot pit section. Extent, 8,000 to 30,000 tons. Formation, windblown sands and silts capping hilltop near crest of moraine.

*Sample No. 8:* SW. ¼ NE. ¼ sec. 15, T. 42 N., R. 8 E. Three-quarters mile north of Carpentersville siding of Chicago and Northwestern Railroad. Worked by Frank Vogel. Sample taken from several channels in several small openings. Pit sections 1 to 4 feet. Extent, 15,000 to 40,000 tons. Formation, windblown sand mantling slope of valley tributary to Fox River valley.

*Sample No. 38:* Location same as No. 2. Sample taken from bin of International Harvester Company, Chicago, Illinois. Used for medium gray iron work.

KENDALL COUNTY

*Sample No. 19:* NW. ¼ NE. ¼ sec. 34, T. 37 N., R. 6 E. One and one-fourth miles south of Plano siding of Chicago, Burlington and Quincy Railroad. Unworked deposit. Owner's name unknown. Sample from several channels in 2- to 3-foot sections exposed in hillside. Bond variable. Extent, 2,000 to 20,000 tons. Locality favorable for similar deposits. Formation, windblown sand on slopes and ridges.

LA SALLE COUNTY

*Sample No. 126:* SW. ¼ NW. ¼ sec. 14, T. 33 N., R. 2 E. On spur of Chicago, Rock Island and Pacific Railroad. Silica sand pit worked by Higbee Canyon Sand Company, Ottawa, Illinois. Sample from iron-stained cap rock. Ordinarily sold as steel sand. Bond and permeability tested wet only. Formation, St. Peter sandstone.

LAWRENCE COUNTY

*Sample No. 195:* NW. ¼ SW. ¼ sec. 3, T. 3 N., R. 11 W. One and one-fourth miles east of Lawrenceville siding of Baltimore and Ohio Railroad. Deposit adjacent to Baltimore and Ohio right-of-way. Unworked deposit. Owner's name unknown. Sample taken from several channels in total 3-foot section. Extent, 30,000 to 120,000 tons. Locality favorable for similar deposits. Formation, windblown sands on terrace of Wabash River. Contains weathered bond only.

MADISON COUNTY

*Sample No. 172:* NW. ¼ SE. ¼ sec. 29, T. 3 N., R. 8 W. One mile north of siding. Worked by Commercial Foundry Sand Company, Collinsville, Illinois. Production for light gray iron, brass and aluminum work. Sample taken from several channels in 2-foot lime-free portion of 4-foot pit section. Sample not a grade as produced but is grade which could be produced in limited quantity. Deposit variable in texture both vertically and horizontally. Extent of any one grade impossible to estimate. Sand of all types 20,000 to 60,000 tons. Formation, windblown sands and silts on slope of east valley wall of Mississippi River. Interbedded textures make any sand produced a combination of weathered bond sand and a primarily deposited bond sand.

*Sample No. 173:* Location same as No. 172. Sample from several channels in 2-foot section of calcareous sand directly overlying the section represented by No. 172. Sample not a produced grade. Total 4-foot section is worked for a produced grade. Formation, same as No. 172.

*Sample No. 175:* Location same as No. 172. Coarsest grade produced. Sample taken from several channels of 3-foot lime-free pit section. Not more than 2,000 tons of this grade available. Formation, same as No. 172.

MARSHALL COUNTY

*Sample No. 127:* SW. ¼ NE. ¼ sec. 4, T. 30 N., R. 2 W. Two miles east of Henry siding of Chicago, Rock Island and Pacific Railroad.

Unworked deposit. Owned by Peter Hank. Sample from single dug hole in upper 2½ feet of total 10-foot section. Lower part of section uniform with sample. Extent, 3,000 to 5,000 tons. Locality favorable for similar deposits. Formation, terrace remnant on east side of Illinois valley.

MCHENRY COUNTY

*Sample No. 9:* NE. ¼ NW. ¼ sec. 34, T. 43 N., R. 8 E. Adjacent to siding of Chicago and Northwestern Railroad. Worked by Garden City Sand Company, Chicago, Illinois. Sample taken from partially loaded car. Total pit section 4 feet. Extent, 50,000 to 100,000 tons. Formation, windblown sand on Fox River terrace.

*Sample No. 21:* SW. ¼ SE. ¼ sec. 16, T. 43 N., R. 8 E. Adjacent to spur of Chicago and Northwestern Railroad. Unworked as molding sand deposit. Sand is overburden on gravel in pit of Consumer's Gravel Company, Chicago, Illinois. Sample taken from several channels in 2- to 3-foot section of finest phase. Extent, 80,000 to 200,000 tons. Formation, windblown sand on gravel outwash plain.

*Sample No. 22:* Location same as No. 21. Sample taken from several channels in 3- to 6-foot section of coarsest phase.

OGLE COUNTY

*Sample No. 54:* S. ½ SE. ¼ sec. 5, T. 25 N., R. 11 E. One mile southwest of Byron siding of Chicago Great Western Railroad. Unworked deposit. Owner's name unknown. Sample taken from 2-foot section exposed in roadcut. Lacking in bond. Surface clay directly overlying might be added to increase bond strength. Extent, 5,000 to 30,000 tons. Locality favorable for similar deposits. Formation, windblown sands capping east valley wall of Rock River. Contains some weathered bond.

*Sample No. 55:* W. ½ SW. ¼ sec. 7, T. 23 N., R. 11 E. One-eighth mile east of Honey Creek siding of Chicago, Burlington and Quincy Railroad. Unworked deposit. Owner's name not known. Sample from single dug hole in total 3-foot section. Extent, 60,000 to 120,000 tons. Locality favorable for other deposits. Formation, terrace sands on broad terrace of Kyte River. Windblown sands containing weathered bond, mantle hill slopes to northeast.

*Sample No. 57:* W. center W. ½ sec. 31, T. 23 N., R. 8 E. Adjacent to paved road five miles south of Oregon siding of Chicago, Burlington and Quincy Railroad. Unworked deposit. Owner's name unknown. Sample from several channels in total 2- to 3-foot section exposed in roadcut. Extent, 10,000 to 60,000 tons. Formation, windblown sand on terrace remnant of Rock River. Sand is derived fron St. Peter sandstone and contains weathered bond.

PEORIA COUNTY

*Sample No. 150:* NW. ¼ SE. ¼ sec. 21, T. 9 N., R. 7 E. Two and one-half miles east of Edwards siding of Chicago, Burlington and

Quincy Railroad. One-eighth mile from Chicago, Burlington and Quincy Railroad right-of-way. Unworked deposit. Owner's name not known. Sample is from upper 3 feet of 10-foot section of uniform texture which is lower part of 25-foot section exposed on west valley wall of Kickapoo Creek. The stratum from which the sample was taken could not be worked alone because of the overburden 15 to 20 feet thick. Extent of total deposit 100,000 to 200,000 tons. Formation, fluvio-glacial sands and silts deposited in still water.

*Sample No. 152:* Location same as No. 150. Sample from calcareous upper 3 feet of 10-foot section of uniform texture. This stratum overlies that represented by No. 150 and is separated from it by 5 feet of very calcareous silt. An overburden at least 5 feet thick covers the entire section and increases to a maximum of 20 feet back from the section. Extent of deposit estimated on basis of quantity available with 5-foot overburden.

*Sample No. 153:* NW. ¼ SW. ¼ sec. 27, T. 9 N., R. 7 E. Two miles west of Pottstown siding of Chicago, Burlington and Quincy Railroad. Unworked deposit. Owner's name unknown. Sample from several channels in upper 4 feet of 15-foot section of uniform texture. Overburden from 3 to 8 feet. Sample slightly calcareous, some parts of section very calcareous. Extent, 60,000 to 200,000 tons. Formation, fluvio-glacial sands underlying high terrace level of Kickapoo Creek.

*Sample No. 154:* SW. ¼ NW. ¼ sec. 17, T. 8 N., R. 8 E. In south part of city of Peoria. Worked by William Worm. Sample taken from several channels in total pit section. Used for heavy gray iron. Extent, 5,000 tons. Formation, windblown sand in low dunes on surface of terrace of Illinois River. Occasional dunes are present on terrace from Henry to Peoria. Contains weathered bond.

### POPE COUNTY

*Sample No. 184:* NW. ¼ SE. ¼ sec. 2, T. 14 S., R. 5 E. One mile south of Brownfield siding of Illinois Central Railroad. Unworked deposit. Owner's name unknown. Sample from uppermost foot of 3-foot section. Extent of deposit of fine sands and silts 180,000 to 1,200,000 tons. Considerable variability in clay and silt content from place to place. Formation, waterlaid fine sands and silts in abandoned river channel.

*Sample No. 185:* Location same as No. 184. Sample taken from lower 2 feet of 3-foot section.

*Sample No. 186:* Location same as No. 184. Sample from total 3-foot section in addition to 6-inch surface layer, which contains little or no humus.

*Sample No. 187:* NW. ¼ NE. ¼ sec. 15, T. 14 S., R. 6 E. Two and one-half miles south of Homberg siding of Illinois Central Railroad. Unworked deposit. Owner's name unknown. Sample from several channels in total 3- to 4-foot section. Extent, 5,000 tons. Locality favorable for similar deposits. Formation, low terrace deposits of abandoned river channel.

*Sample No. 188:* NW. ¼ SE. ¼ sec. 4, T. 14 S., R 6 E. Adjacent to Homberg siding of Illinois Central Railroad. Unworked deposit. On right-of-way of Illinois Central Railroad. Sample from several channels in total 2-foot section. Extent, 5,000 tons. Locality favorable for similar deposits. Formation, windblown sand in dunes on highest terrace of abandoned river channel.

*Sample No. 189:* NE. ¼ NW. ¼ sec. 2, T. 13 S., R. 5 E. Two and one-half miles south of Brownfield siding of Illinois Central Railroad. Part of deposit mentioned under No. 184. Sample from single dug hole in 3-foot total section. Surface silt not included.

PULASKI COUNTY

*Sample No. 183:* NW. ¼ NE. ¼ sec. 22, T. 15 S., R. 1 W. One-half mile south of Pulaski. Sample contains only iron oxide bond. From deposit of no commercial value. Formation, Tertiary sands.

RANDOLPH COUNTY

*Sample No. 181:* SW. ¼ NE. ¼ sec. 28, T. 7 S., R. 6 W. Adjacent to Clores siding of Wabash, Chester and Western Railroad. Abandoned pit. Owner's name not known. Sample taken from upper 3 feet of 7-foot section. Extent, 20,000 to 50,000 tons. Formation, interbedded sands and silts on terrace of St. Mary's River. "Vegetable" or reduced clay bond.

ROCK ISLAND COUNTY

*Sample No. 78:* W. ½ sec. 3, T. 17 N., R. 2 W. Deposit adjacent to siding of Chicago, Rock Island and Pacific Railroad. Worked by Rock Island Molding Sand Company, Rock Island. Sample taken from 2½-foot pit section. Extent of deposit 120,000 to 600,000 tons. Formation, alluvium. Has "vegetable" or reduced clay bond. Deposit subject to the textural variations normal to deposits containing primarily deposited bond.

*Sample No. 79:* Location same as No. 78. Sample from dug hole in 2-foot section.

*Sample No. 84:* Location same as No. 102. Sample taken from bin of John Deere Harvester Works, East Moline. Used for light castings and as core filler.

*Sample No. 85:* Exact locality unknown. Reported to come from small island in Mississippi River. Was used locally at one time. Locally called "Mud Island" sand. Sample taken from remnant in bins of John Deere Harvester Works, East Moline. Formation, apparently alluvium. Has "vegetable" or reduced clay bond. Bond primarily deposited.

*Sample No. 102:* NE. ¼ NW. ¼ sec. 14, T. 17 N., R. 2 W. One-eighth mile from siding of Chicago, Rock Island and Pacific Railroad. Worked by T. B. and S. S. Davis. Total section 15 to 20 feet. Sample taken from bin of Frank Foundries, Moline. Used for small castings and for core filler. Extent of deposit, 5,000 to 15,000 tons. Formation, windblown silts on slope of north valley wall of Rock River. Bond primarily deposited. Calcareous except at base of section.

*Sample No. 105:* SW. ¼ NW. ¼ sec. 34, T. 18 N., R. 2 W. On the property of and adjacent to Blake Foundries Specialty Company, Rock Island. Sample taken from lower 3 feet of total 7-foot section. Used for light and medium castings. Formation, alluvium. Contains "vegetable" or reduced clay bond.

*Sample No. 106:* NW. ¼ SW. ¼ sec. 29, T. 18 N., R. 1 E. Adjacent to siding of Chicago, Rock Island and Pacific Railroad. Worked by Rock Island Molding Sand Company. Sample from several channels in total 2-foot section. Extent, 10,000 to 60,000 tons. Formation, sands in terrace remnant of old channel.

*Sample No. 110:* SE. ¼ SW. ¼ sec. 22, T. 17 N., R. 2 W. One and one-fourth miles west of Milan. Adjacent to Chicago, Rock Island and Pacific Railroad right-of-way. Unworked deposit. Owner's name unknown. Sample from single dug hole in 3-foot section. Extent, 9,000 to 20,000 tons. Locality favorable for similar deposits. Formations, fine sands and silts on broad terrace of Rock River.

SANGAMON COUNTY

*Sample No. 156:* SW. ¼ NE. ¼ sec. 4, T. 17 N., R. 4 W. One-fourth mile northwest of Spaulding siding of Illinois Central Railroad. Unworked deposit. Owner's name unknown. Sample from several channels in 2- to 3-foot section, exposed in roadcut. Extent, 10,000 to 15,000 tons. Formation, windblown sand capping east valley wall of Sangamon River. Contains weathered bond.

ST. CLAIR COUNTY

*Sample No. 180:* NE. ¼ SE. ¼ sec. 7, T. 2 N., R. 8 W. One-eighth mile from Caseyville siding of Baltimore and Ohio Railroad. Owned and worked by O. J. Long, Caseyville. Sample from calcareous lower 6 feet of 18-foot section. Extent, 10,000 tons. Formation, windblown silt or loess on slope of east valley wall of the Mississippi.

SHELBY COUNTY

*Sample No. 196:* T. 10 N., R. 4 W. Two and one-half miles northwest of Fancher. One-half mile east of Kaskaskia River. Forest Howe, owner. Sample from dug hole in 2½-foot section. Extent, 12,000 tons. Formation, windblown sand capping hilltop. Contains weathered bond.

TAZEWELL COUNTY

*Sample No. 155:* NE. ¼ SW. ¼ sec. 13, T. 25 N., R. 5 W. Three miles north of Pekin. One-fourth mile east of Chicago, Peoria and St. Louis Railroad right-of-way. Unworked deposit. Owner's name unknown. Sample from several channels in 2- to 4-foot section exposed in roadcut. Extent, 200,000 to 500,000 tons. Locality very favorable for similar deposits. Formation, windblown sand on terrace of Illinois River. Contains weathered bond.

WHITE COUNTY

*Sample No. 192:* SE. ¼ SW. ¼ sec. 8, T. 5 S., R. 10 E. One and one-half miles east of Carmi siding of Big Four Railroad. Unworked deposit. Owner's name unknown. Sample from total 3½-foot section; 1½ feet very heavy, 2 feet open. Extent, 42,000 tons. Several deposits in locality. Formation, windblown sand in dunes on terrace of Wabash River. Contains weathered bond.

*Sample No. 193:* NW. ¼ SE. ¼ sec. 11, T. 5 S., R. 10 E. Three and one-half miles southeast of Simpson siding of Big Four Railroad. Sample of several channels in total 3½-foot section. Extent, 40,000 to 100,000 tons. Locality favorable for similar deposits. Formation same as No. 192.

*Sample No. 194:* S. ½ sec. 29, T. 3 S., R. 11 E. One and one-fourth miles south of Grayville siding. Unworked deposit. Owner's name unknown. Sample from several channels in 2- to 4-foot section. Extent, 20,000 to 240,000 tons. Locality favorable for similar deposits. Formation, windblown sand on terrace of Wabash River.

WHITESIDE COUNTY

*Sample No. 65:* SW. ¼ NW. ¼ sec. 25, T. 21 N., R. 5 E. One-eighth mile west of Round Grove siding of Chicago and Northwestern Railroad. Owner, Clare Knox. Lessee, Garden City Sand Company. Sample from upper 5 feet of total 10-foot pit section, calcareous. Extent, 24,000 to 50,000 tons. Formation, windblown silt or loess capping ridge.

*Sample No. 66:* Location same as No. 65. Sample from calcareous lower 5 feet of total 10-foot pit section.

*Sample No. 68:* NE. ¼ NW. ¼ sec. 32, T. 21 N., R. 4 E. Three miles north of Fenton siding. Deposit adjacent to Chicago, Burlington and Quincy right-of-way. Unworked deposit. Owner, Harry Hanzinga, Fenton. Sample from several channels in 2-foot section exposed in roadcut. Extent, 48,000 to 80,000 tons. Formation, windblown sand on southeast valley wall of abandoned channel.

*Sample No. 69:* Location same as No. 68. Sample from several sections at higher level.

WILL COUNTY

*Sample No. 11:* S. ½ sec. 18, T. 32 N., R. 10 E. One-fourth mile from siding of Wabash Railroad. Worked by Larson and Larson. Sample taken from partially loaded car. Pit section 2 to 4 feet. Extent, 40,000 tons. Formation, sand terrace of Kankakee River. Weathered bond.

*Sample No. 12:* S. ½ sec. 18, T. 32 N., R. 10 E. One-eighth mile west of Wabash Railroad siding. Worked by Riverside Sand Company, Custer Park, Illinois. Sample taken from partially loaded car. From 3-foot pit section. Extent, 20,000 to 60,000 tons. Formation, windblown sand on terrace of Kankakee River.

*Sample No. 13:* Location same as No. 12. Sample from several dug holes in 2-foot section. Formation same as No. 12.

*Sample No. 15:* Location same as No. 12. Sample taken from dug hole in upper 2 feet of 4- to 6-foot section underlying pit sections mentioned under Nos. 12 and 13. Extent, 10,000 to 15,000 tons. Formation, terrace sands of Kankakee River. Contains weathered bond.

*Sample No. 39:* E. ½ sec. 12, T. 33 N., R. 9 E. One-eighth mile east of siding of Chicago and Alton Railroad. Worked by Rockton Molding Sand Co., Rockton, Illinois. Sample taken from several channels in 2½-foot section exposed in roadcut. Extent, 32,000 to 120,000 tons. Formation, windblown sand mantling slope at east edge of wide flat. Weathered bond.

*Sample No. 40:* Location same as No. 39. Sample taken from several channels in 2-foot section of second roadcut.

WINNEBAGO COUNTY

*Sample No. 46:* NE. ¼ sec. 25, T. 46 N., R. 1 E. One mile south of Chicago, Milwaukee and St. Paul Railroad siding. Worked by Rockton Molding Sand Company, Rockton, Illinois. Sample taken from 2-foot pit section. Extent of whole deposit 50,000 to 300,000 tons. Formations, windblown sands on slope and capping valley wall of Rock River.

*Sample No. 47:* Location same as No. 46. Sample taken from dug hole in upper 3 feet of 5-foot section. From upper slopes.

*Sample No. 48:* Location same as No. 46. Sample from 2-foot pit section in abandoned opening.

*Sample No. 49:* Location same as No. 46. Sample dug from 3-foot pit section by machine. This material is mechanically mixed with No. 46 to form one produced grade.

*Sample No. 50:* S. ½ sec. 24, T. 46 N., R. 1 E. Worked by Rockton Molding Sand Company, Rockton, Illinois. Sample from lower 6 feet of 8-foot pit section. Calcareous. Extent, 5,000 tons. Formation, windblown silt or loess on slope of south valley wall of Rock River.

"FOREIGN" MOLDING SANDS USED IN ILLINOIS

ALBANY, NEW YORK, NO. 1

*Sample No. 180:* Decatur Malleable Iron Company, Decatur, Illinois. Used for bond renewal and for small castings.

ALBANY, NEW YORK

*Sample No. 103:* Rock Island Stove Company, Rock Island, Illinois. Used for stove plate.

*Sample No. 104:* Rock Island Stove Company, Rock Island, Illinois. Used for stove plate.

BAUMAN, INDIANA

*Sample No. 25:* Houghland and Hardy, Evansville, Indiana. Sample from Greenlee Brothers, Chicago, Illinois.

*Sample No. 30:* Houghland and Hardy, Evansville, Indiana. Western Foundry Company, Chicago. Light brass and aluminum casting.

BELOIT, WISCONSIN

*Sample No. 24:* Greenlee Brothers, Chicago. Used for heavy castings.

BELOIT, WISCONSIN, "NORTHWESTERN"

*Sample No. 35:* Crane Company, Chicago. Used for medium heavy castings.

CONNEAUT, OHIO, "NASH"

*Sample No. 27:* Western Foundry Company, Chicago. Used for slightly heavier work than No. 30.

BAUMAN, INDIANA, AND CONNEAUT, OHIO

*Sample No. 28:* Half and half mix made for some types of work. Western Foundry Company, Chicago.

CONNEAUT, OHIO

*Sample No. 91:* Tri-City Malleable Company, Moline, Illinois. Not suitable for malleable work.

NEWPORT, KENTUCKY, "DYETON"

*Sample No. 34:* Crane Company, Chicago. Used for light work.

NEWCASTLE, INDIANA, "BRADFORD"

*Sample No. 33:* Crane Company, Chicago. Used for medium weight castings.

*Sample No. 36:* National Malleable and Steel Casting Company, Chicago. Used for very heavy work.

RIDGEWAY, PENNSYLVANIA

*Sample No. 198:* American Refractories Company. Synthetic sand with fire clay bond. Sample sent in.

ZANESVILLE, OHIO

*Sample No. 29:* Western Foundry Company. Used for heavy castings and for opener with close sands.

*Sample No. 32:* Western Foundry Company, Chicago. Used for medium work.

## Results of Tests

The results of tests made on samples collected during the progress of the molding-sand investigation are given in the following tables, 30 and 31.

## Classification of Undeveloped Deposits of Illinois Natural-Bonded Molding Sand

The value of any given molding sand deposit is determined by so many factors that its correct evaluation is difficult. Assuming that the

molding sand produced is of good quality, the factors of extent of deposit and distance to shipping point may determine commercial value, especially in the cases of undeveloped deposits. In the cases of developed deposits, the distance to shipping point is significant chiefly in pointing out the probable limit of distance on undeveloped deposits. The extent of a deposit is in some measure a criterion of the possibility of long-time production. This is distinct from the long-time production of uniform grades of molding sand, which is a function of the degree of variability of the molding sand in the deposit. This latter is discussed in a general way in Chapter III and is touched upon more specifically in Chapter IV.

Even though the extent of the deposit and its distance from a shipping point are of basic importance when estimates are to be made of the value of a developed deposit, it has been deemed unwise and unfair to include a classification of the developed deposits of the State, because evaluations made in this manner leave out another basic factor—the value of the produced sand. This factor is proportional to the skill of the producer, for when the sand comes on the market, it is judged not by extent of the deposit or distance from shipping point, but by quality. A deposit relatively distant from a shipping point in the hands of an expert producer would be a source of considerably greater profit than an equally good deposit on a railroad worked by an unskilled producer.

The classification of the undeveloped deposits in Table 32 is based solely on the distance to a shipping point, because the factors of extent and quality of undeveloped deposits are too highly problematical to justify their use. The Class A deposits are those one mile or less from a shipping point; and the Class B deposits are those more than one mile from a shipping point.

TABLE 30.—*Results of tests on Illinois molding sands*[1]

| Lab. No. | County[2] | Grade if Used | Screen Analysis | | | | | | | | | | | | Water Per cent | Bond Strength | Permeability | Dye Adsorption[3] | Per cent Loss Bond Strengt at 600° F. | Base Permeability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | On 6 | On 12 | On 20 | On 40 | On 70 | On 100 | On 140 | On 200 | On 270 | Through 270 | Clay | Total | | | | | | |
| 139 | Adams.... | Produced.. (Calcium carbonate present.) | .... | .... | .... | .6 | 2.6 | 1.6 | 1.2 | 2.7 | 2.4 | 75.3 | 13.0 | 99.4 | 4<br>6<br>8 | 231.6<br>238.3<br>**224.9** | 3.7<br>**3.8**<br>3.6 | 1260 | 14.3 | 4.6 |
| 52 | Bond..... | Produced.. | .... | .... | .1 | .3 | 40.3 | 21.1 | 8.6 | 5.1 | 1.0 | 4.9 | 17.6 | 99.0 | 4<br>6<br>8 | .....<br>**312.3**<br>276.5 | **83.6**<br>69.6<br>54.5 | 1840 | ... | 89.5 |
| 53 | Bond..... | Produced.. | .... | .... | .02 | .6 | 39.0 | 14.2 | 5.1 | 4.1 | 1.1 | 16.7 | 18.8 | 99.62 | 4<br>6<br>8 | .....<br>**235.2**<br>210.3 | **47.8**<br>44.0<br>37.4 | 1360 | .... | 19.8 |
| 100 | Bond..... | Produced.. | 2.0 | .5 | 1.6 | 4.7 | 31.8 | 13.6 | 10.2 | 4.2 | .9 | 8.7 | 21.1 | 99.3 | 4<br>6<br>8 | 314.2<br>**321.5**<br>306.5 | **92.8**<br>89.5<br>51.2 | 3376 | .... | 60.5 |
| 166 | Bond..... | Possible... | .... | 1.0 | 1.4 | 4.0 | 42.8 | 18.6 | 8.2 | 4.6 | 1.4 | 3.8 | 14.0 | 99.8 | 4<br>6<br>8 | **302.4**<br>289.1<br>212.7 | **92.8**<br>83.5<br>56.2 | 1768 | 32.2 | 82.4 |
| 167 | Bond..... | Produced.. | .... | .6 | .6 | 3.4 | 31.0 | 15.8 | 9.8 | 11.0 | 3.2 | 7.6 | 16.0 | 99.0 | 4<br>6<br>8 | **336.7**<br>311.1<br>292.7 | 46.6<br>**48.6**<br>30.3 | 1872 | .... | 30.9 |
| 168 | Bond..... | Produced.. | .... | .2 | .4 | .8 | 27.8 | 15.6 | 9.2 | 6.4 | .8 | 10.0 | 28.0 | 99.2 | 4<br>6<br>8 | 336.6<br>325.7<br>**346.4** | 77.6<br>**78.8**<br>41.5 | 3072 | .... | 121.6 |
| 170 | Bond..... | Produced.. | .... | 2.2 | 4.0 | 9.8 | 18.0 | 8.8 | 13.8 | 3.4 | .8 | 13.4 | 25.0 | 99.2 | 4<br>6<br>8 | 281.0<br>303.1<br>**319.0** | 66.3<br>**86.7**<br>76.8 | 2608 | 4.9 | 108.0 |
| 171 | Bond..... | Possible... | .... | .2 | 3.0 | 24.6 | 45.0 | 1.8 | 1.0 | 1.0 | .2 | 4.0 | 18.4 | 99.2 | 4<br>6<br>8 | 299.4<br>**336.6**<br>326.1 | **432.0**<br>248.6<br>152.5 | 1920 | 28.1 | 378.7 |
| 179 | Bond..... | Produced.. | .5 | .5 | .9 | 2.0 | 39.0 | 26.2 | 6.4 | 2.2 | .4 | 4.4 | 16.4 | 98.4 | 4<br>6<br>8 | **290.0**<br>278.1<br>254.7 | **104.4**<br>96.4<br>62.8 | 185[illegible] | .... | 105.3 |
| 43 | Boone..... | Possible... | .... | .... | .8 | 7.2 | 37.4 | 11.2 | 4.6 | 3.4 | 1.2 | 10.4 | 23.0 | 99.2 | 4<br>6<br>8 | .....<br>**329.7**<br>325.2 | .....<br>**83.5**<br>58.3 | 2060 | .... | 94.5 |
| 113 | Bureau..... | Possible... | .... | .... | .... | 1.0 | 34.6 | 21.6 | 11.0 | 7.2 | 1.8 | 12.0 | 10.0 | 99.2 | 4<br>6<br>8 | **231.1**<br>185.3<br>147.4 | **43.2**<br>39.2<br>26.7 | 1720 | 25.6 | 23.2 |
| 114 | Bureau..... | Possible... | .... | .... | .... | .6 | 30.6 | 25.8 | 10.4 | 7.8 | 2.4 | 9.4 | 12.0 | 99.0 | 4<br>6<br>8 | **283.2**<br>232.3<br>174.4 | **64.2**<br>43.2<br>29.9 | 2640 | 19.8 | 28.2 |
| 115 | Bureau..... | Produced.. | .... | .... | .... | .4 | 26.8 | 22.4 | 9.4 | 5.8 | 1.8 | 13.4 | 19.0 | 99.0 | 4<br>6<br>8 | 245.8<br>**266.9**<br>251.0 | **50.1**<br>41.8<br>37.4 | 2840 | .... | 23.8 |
| 116 | Bureau..... | Produced.. | .... | .... | .... | 1.4 | 35.6 | 27.8 | 10.8 | 5.0 | .6 | 6.3 | 11.6 | 99.1 | 4<br>6<br>8 | **231.7**<br>183.4<br>138.5 | **69.6**<br>54.5<br>42.5 | 1840 | 16.5 | 53.9 |
| 117 | Bureau..... | Possible... | .... | .... | .... | 2.0 | 37.4 | 25.4 | 11.0 | 5.0 | .6 | 5.4 | 12.4 | 99.2 | 4<br>6<br>8 | **212.5**<br>171.0<br>133.5 | **71.6**<br>51.2<br>36.9 | 1404 | ..... | 45.3 |
| 138 | Cass..... | Produced.. | .... | .... | .... | .02 | 14.2 | 19.2 | 14.6 | 7.2 | 3.3 | 26.6 | 14.8 | 99.92 | 4<br>6<br>8 | **205.9**<br>192.7<br>167.8 | **26.9**<br>19.7<br>15.1 | 1600 | **4.3**<br>gain | 20.7 |
| 143 | Cass..... | Possible... | .... | .... | .... | .... | 29.0 | 32.6 | 12.0 | 7.0 | 1.0 | 5.6 | 12.4 | 99.6 | 4<br>6<br>8 | **254.8**<br>179.1<br>144.5 | **61.1**<br>47.5<br>36.3 | 1872 | 22.8 | 37.7 |

[1]Bold-face figures indicate the best developed bond strength and permeability.
[2]Precise locations are given on pages 148-151.
[3]Dye adsorption tests by Mr. W. M. Saunders, Chairman Joint Committee on Molding Sand Research.

TABLE 30.—*Results of tests on Illinois molding sands*[1]—Continued

| Lab. No. | County[2] | Grade if Used | Screen Analysis | | | | | | | | | | | | Water Per cent | Bond Strength | Permeability | Dye Adsorption | Per cent Loss Bond Strength at 600° F. | Base Permeability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | On 6 | On 12 | On 20 | On 40 | On 70 | On 100 | On 140 | On 200 | On 270 | Through 270 | Clay | Total | | | | | | |
| 144 | Cass | Possible | .... | .... | .... | .... | 18.0 | 22.6 | 12.8 | 9.4 | 2.6 | 18.2 | 16.0 | 99.6 | 4 | **198.8** | 19.4 | | | |
| | | | | | | | | | | | | | | | 6 | 191.7 | **21.1** | 1680 | .... | 10.6 |
| | | | | | | | | | | | | | | | 8 | 156.6 | 18.3 | | | |
| 145 | Cass | Possible | .... | .... | .... | .... | 12.6 | 13.8 | 9.2 | 11.0 | 4.6 | 35.6 | 12.5 | 99.3 | 4 | **216.0** | **9.9** | | | |
| | | | | | | | | | | | | | | | 6 | 193.3 | 9.3 | 1408 | .... | 8.2 |
| | | | | | | | | | | | | | | | 8 | 173.2 | 9.6 | | | |
| 146 | Cass | No Value (Calcium carbonate present.) | .... | .... | .... | 1.4 | 16.4 | 16.4 | 9.0 | 9.0 | 3.2 | 26.6 | 17.0 | 99.0 | 4 | **196.4** | 8.1 | | | |
| | | | | | | | | | | | | | | | 6 | 191.9 | 7.7 | 1240 | .... | 9.3 |
| | | | | | | | | | | | | | | | 8 | 189.2 | **8.3** | | | |
| 147 | Cass | Possible? | .... | .... | .... | .... | 11.0 | 11.8 | 5.6 | 4.2 | 2.4 | 44.0 | 20.0 | 99.0 | 4 | 203.4 | **4.5** | | | |
| | | | | | | | | | | | | | | | 6 | **251.1** | 4.3 | 1904 | .... | 4.4 |
| | | | | | | | | | | | | | | | 8 | 231.6 | 4.1 | | | |
| 177 | Cass | Produced | .... | .... | .... | .02 | 13.1 | 24.0 | 18.4 | 15.6 | 3.3 | 14.2 | 9.68 | 98.3 | 4 | **186.1** | **30.6** | | | |
| | | | | | | | | | | | | | | | 6 | 161.7 | 29.5 | 1376 | .... | 26.2 |
| | | | | | | | | | | | | | | | 8 | 132.9 | 24.4 | | | |
| 197 | Clinton | Possible? | .... | .3 | .7 | 2.4 | 31.2 | 11.3 | 4.8 | 4.9 | 1.4 | 15.9 | 26.4 | 99.3 | 4 | 270.6 | **56.8** | | | |
| | | | | | | | | | | | | | | | 6 | 270.7 | 41.2 | 1872 | .... | 10.8 |
| | | | | | | | | | | | | | | | 8 | **279.3** | 3.8 | | | |
| 10 | Cook | Possible | .... | .... | .... | .... | 5.0 | 21.0 | 20.6 | 19.0 | 3.4 | 7.4 | 22.6 | 99.0 | 4 | 312.7 | **54.2** | | | |
| | | | | | | | | | | | | | | | 6 | **322.4** | 43.7 | 3060 | .... | 31.4 |
| | | | | | | | | | | | | | | | 8 | 309.3 | 33.5 | | | |
| 37 | Fayette | Produced | .... | .... | .... | .06 | 27.4 | 25.0 | 14.1 | 11.8 | 2.0 | 3.9 | 14.5 | 98.76 | 4 | **254.1** | **71.6** | | | |
| | | | | | | | | | | | | | | | 6 | 224.4 | 53.3 | 1920 | .... | 43.7 |
| | | | | | | | | | | | | | | | 8 | 207.0 | 55.7 | | | |
| 161 | Fayette | Possible | .... | 1.2 | 1.6 | 2.8 | 29.0 | 19.8 | 6.7 | 4.2 | 2.0 | 9.8 | 22.4 | 99.5 | 4 | ..... | ..... | | | |
| | | | | | | | | | | | | | | | 6 | **319.2** | 50.0 | 1856 | .... | 71.4 |
| | | | | | | | | | | | | | | | 8 | 288.6 | **57.1** | | | |
| 162 | Fayette | Possible | .... | .2 | .2 | 1.8 | 37.8 | 23.0 | 9.6 | 8.4 | 2.0 | 5.0 | 11.0 | 99.0 | 4 | **329.9** | **61.9** | | | |
| | | | | | | | | | | | | | | | 6 | 326.0 | 57.3 | 2720 | .... | 55.2 |
| | | | | | | | | | | | | | | | 8 | 314.2 | 49.0 | | | |
| 163 | Fayette | Produced | .... | 1.8 | 3.8 | 15.4 | 45.0 | 9.0 | 3.0 | 2.4 | .4 | 4.2 | 14.0 | 99.0 | 4 | **284.8** | **182.9** | | | |
| | | | | | | | | | | | | | | | 6 | 269.4 | 135.7 | 1440 | .... | 110.9 |
| | | | | | | | | | | | | | | | 8 | 220.0 | 104.4 | | | |
| 164 | Fayette | Possible | .... | .... | .... | .... | 32.0 | 22.0 | 13.2 | 11.6 | 1.2 | 1.8 | 17.6 | 99.4 | 4 | **341.3** | **100.3** | | | |
| | | | | | | | | | | | | | | | 6 | 321.7 | 92.8 | 2600 | .... | 66.3 |
| | | | | | | | | | | | | | | | 8 | 283.3 | 67.8 | | | |
| 165 | Fayette | Possible | .... | 1.8 | 2.8 | 7.0 | 51.2 | 7.4 | 3.2 | 3.0 | 1.0 | 6.0 | 16.0 | 99.4 | 6 | 315.3 | 50.6 | | | |
| | | | | | | | | | | | | | | | 8 | 315.4 | **70.4** | 2976 | .... | 127.1 |
| | | | | | | | | | | | | | | | 10 | **339.9** | 69.4 | | | |
| 169 | Fayette | Produced | .... | .... | .... | 1.0 | 39.8 | 20.4 | 6.6 | 3.8 | .4 | 6.4 | 20.6 | 99.0 | 4 | **320.7** | 72.0 | | | |
| | | | | | | | | | | | | | | | 6 | 301.7 | **80.8** | 2208 | .... | 49.7 |
| | | | | | | | | | | | | | | | 8 | 295.4 | 59.2 | | | |
| 190 | Gallatin | Possible | .... | .... | .... | .... | 9.0 | 17.0 | 13.0 | 12.0 | 5.0 | 26.0 | 17.0 | 99.0 | 4 | **181.5** | **18.0** | | | |
| | | | | | | | | | | | | | | | 6 | 167.9 | 17.5 | 1120 | 8.8 | 16.2 |
| | | | | | | | | | | | | | | | 8 | 153.4 | 15.7 | | | |
| 191 | Gallatin | Possible | .... | .... | .... | .... | 11.0 | 21.4 | 16.0 | 13.0 | 4.0 | 11.4 | 22.6 | 99.4 | 6 | **333.1** | **31.7** | | | |
| | | | | | | | | | | | | | | | 8 | 326.0 | 26.7 | 2880 | .... | 26.9 |
| | | | | | | | | | | | | | | | 10 | 320.6 | 21.4 | | | |
| 137 | Hancock | "No. 2" | .... | .... | .... | .... | .2 | 1.4 | 4.0 | 7.0 | 6.0 | 53.0 | 28.0 | 99.6 | 4 | 245.0 | **7.5** | | | |
| | | | | | | | | | | | | | | | 6 | **282.1** | **7.5** | 3640 | .... | 7.2 |
| | | | | | | | | | | | | | | | 8 | 263.4 | 7.2 | | | |
| 149 | Hancock | Produced | .... | .... | .... | .04 | 1.8 | 3.0 | 3.1 | 6.8 | 4.4 | 64.2 | 16.4 | 99.74 | 4 | 255.0 | **6.5** | | | |
| | | | | | | | | | | | | | | | 6 | **286.5** | 5.4 | 3072 | .... | 6.4 |
| | | | | | | | | | | | | | | | 8 | 257.0 | 4.2 | | | |

[1]Bold-face figures indicate the best developed bond strength and permeability.
[2]Precise locations are given on pages 150-153.

TABLE 30.—*Results of tests on Illinois molding sands*[1]—Continued

| Lab. No. | County[2] | Grade if Used | Screen Analysis | | | | | | | | | | | | Water Per cent | Bond Strength | Permeability | Dye Adsorption | Per cent Loss Bond Strength at 600° F. | Base Permeability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | On 6 | On 12 | On 20 | On 40 | On 70 | On 100 | On 140 | On 200 | On 270 | Through 270 | Clay | Total | | | | | | |
| 86 | Henderson.. | Produced.. | .... | .2 | .02 | .4 | 11.3 | 11.3 | 9.6 | 11.6 | 4.6 | 38.2 | 11.8 | 99.02 | 4<br>6<br>8 | .....<br>**212.9**<br>192.1 | **12.5**<br>8.7<br>10.9 | 1640 | .... | 13.4 |
| 101 | Henderson.. | Produced.. | .... | .1 | .3 | 2.0 | 18.7 | 12.1 | 9.3 | 13.0 | 5.0 | 29.1 | 9.4 | 99.0 | 4<br>6<br>8 | 181.5<br>**197.8**<br>173.8 | **13.2**<br>13.0<br>12.6 | 1480 | .... | 11.3 |
| 128 | Henderson.. | Possible... (Calcium carbonate present.) | .... | .... | .... | .... | .... | .8 | 1.6 | 6.6 | 6.9 | 78.2 | 5.0 | 99.1 | 4<br>6<br>8 | 147.0<br>169.5<br>**172.8** | 7.1<br>**7.2**<br>6.9 | 976 | .... | 9.0 |
| 130 | Henderson.. | Produced.. | .... | .... | .... | 2.2 | 16.0 | 13.0 | 7.6 | 8.2 | 2.8 | 31.8 | 17.6 | 99.2 | 4<br>6<br>8 | 225.7<br>**248.9**<br>221.9 | **19.3**<br>18.1<br>15.7 | 1680 | 11.4 | 12.1 |
| 131 | Henderson.. | Possible... | .... | .... | .... | .... | 14.0 | 15.4 | 9.0 | 7.4 | 3.0 | 29.4 | 21.0 | 99.2 | 4<br>6<br>8 | 278.2<br>**281.3**<br>266.8 | 21.4<br>**26.7**<br>21.1 | 2870 | .... | 11.9 |
| 132 | Henderson.. | Possible... | .... | .... | .... | 4.2 | 32.0 | 7.4 | 3.4 | 8.4 | 3.4 | 18.2 | 22.2 | 99.2 | 4<br>6<br>8 | .....<br>**298.0**<br>269.4 | .....<br>**23.2**<br>16.5 | 2040 | .... | 14.7 |
| 133 | Henderson.. | "No. 2 Open".. | .... | .... | .... | .... | 5.4 | 6.6 | 6.3 | 11.8 | 6.2 | 40.4 | 22.4 | 99.1 | 4<br>6<br>8 | 237.2<br>**250.0**<br>241.6 | **11.6**<br>10.4<br>5.7 | 1660 | 21.1 | 8.4 |
| 134 | Henderson.. | "No. 1 Open".. | .... | .... | .... | .3 | 6.2 | 12.1 | 20.1 | 28.3 | 7.3 | 17.2 | 8.0 | 99.5 | 4<br>6<br>8 | **188.4**<br>149.8<br>133.6 | 23.2<br>**25.6**<br>21.8 | 1088 | .... | 21.3 |
| 142 | Henderson.. | Produced.. | .... | .... | .... | .... | 13.8 | 17.6 | 11.0 | 11.0 | 2.4 | 26.4 | 16.0 | 98.2 | 4<br>6<br>8 | **230.0**<br>216.2<br>188.4 | **18.5**<br>16.0<br>14.5 | 2256 | .... | 18.4 |
| 176 | Henderson.. | Produced.. | .... | .... | .... | .1 | 8.3 | 12.3 | 14.9 | 21.8 | 7.6 | 27.9 | 5.8 | 98.7 | 4<br>6<br>8 | **151.5**<br>147.9<br>136.1 | **15.9**<br>14.5<br>13.7 | 1040 | .... | 14.5 |
| 76 | Henry..... | Possible... | .... | .... | .... | .... | 23.0 | 26.0 | 13.4 | 11.2 | 2.6 | 12.8 | 10.2 | 99.2 | 4<br>6<br>8 | **204.7**<br>179.1<br>159.6 | 23.2<br>**28.5**<br>24.4 | 1320 | .... | 17.3 |
| 77 | Henry..... | Possible... | .... | .... | .... | 1.6 | 27.0 | 17.4 | 7.4 | 4.6 | 1.4 | 21.0 | 18.0 | 98.4 | 4<br>6<br>8 | 189.6<br>**201.7**<br>186.6 | 9.8<br>12.2<br>**13.7** | 1280 | .... | 7.6 |
| 83 | Henry..... | Produced.. | .... | .1 | .06 | .3 | 13.5 | 17.4 | 12.6 | 10.1 | 2.9 | 27.3 | 14.1 | 98.36 | 4<br>6<br>8 | **222.8**<br>214.8<br>209.7 | 15.7<br>**16.6**<br>12.6 | 1488 | 25.7 | 13.7 |
| 88 | Henry..... | "No. 5"... | .... | .... | .... | .2 | 9.5 | 15.9 | 13.5 | 12.0 | 5.3 | 34.6 | 7.6 | 98.6 | 4<br>6<br>8 | **234.4**<br>223.1<br>191.7 | 9.8<br>**10.2**<br>8.1 | 1712 | 11.2 | 12.7 |
| 93 | Henry..... | Possible?.. | .... | .... | .... | 2.6 | 30.0 | 10.6 | 15.4 | 18.2 | 3.4 | 7.8 | 10.6 | 98.6 | 4<br>6<br>8 | **209.8**<br>175.5<br>134.4 | **35.3**<br>32.6<br>29.6 | 1480 | 17.9 | 44.3 |
| 94 | Henry..... | Possible?.. | .... | .... | .... | .4 | 17.4 | 17.8 | 18.0 | 19.6 | 4.0 | 10.0 | 12.0 | 99.2 | 4<br>6<br>8 | **198.0**<br>188.4<br>156.6 | **36.4**<br>34.8<br>30.9 | 1400 | .... | 36.8 |
| 95 | Henry..... | Possible... | .... | .... | .... | .... | 5.0 | 11.8 | 21.6 | 28.4 | 5.8 | 11.9 | 14.7 | 99.2 | 4<br>6<br>8 | 251.7<br>**262.4**<br>228.1 | 23.2<br>**27.8**<br>20.4 | 2224 | .... | 29.4 |
| 99 | Henry..... | "No. 6"... | .... | .... | .... | .4 | 16.4 | 25.2 | 15.6 | 10.0 | 3.0 | 17.2 | 11.4 | 99.2 | 4<br>6<br>8 | **167.4**<br>158.7<br>136.2 | 23.2<br>**24.5**<br>20.0 | 1280 | .... | 16.4 |

[1]Bold-face figures indicate the best developed bond strength and permeability.
[2]Precise locations are given on pages 153-155.

TABLE 30.—*Results of tests on Illinois molding sands*[1]—Continued

| Lab. No. | County[2] | Grade if Used | Screen Analysis | | | | | | | | | | | | Water Per cent | Bond Strength | Permeability | Dye Adsorption[3] | Per cent Loss Bond Strength at 600° F. | Base Permeability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | On 6 | On 12 | On 20 | On 40 | On 70 | On 100 | On 140 | On 200 | On 270 | Through 270 | Clay | Total | | | | | | |
| 111 | Henry..... | Possible... | .... | .... | .... | .... | 3.8 | 2.2 | 3.4 | 5.6 | 2.5 | 58.0 | 23.0 | 98.5 | 4 | ..... | 6.5 | 3840 | 8.2 | 11.6 |
| | | | | | | | | | | | | | | | 6 | **292.5** | **8.0** | | | |
| | | | | | | | | | | | | | | | 8 | 291.0 | 7.7 | | | |
| 112 | Henry..... | Possible... | .... | .... | .... | .... | 2.0 | 30.8 | 31.4 | 15.4 | 2.4 | 4.2 | 13.0 | 99.2 | 4 | **269.5** | 49.7 | 2240 | .... | 43.3 |
| | | | | | | | | | | | | | | | 6 | 242.2 | **55.7** | | | |
| | | | | | | | | | | | | | | | 8 | 188.7 | 34.4 | | | |
| 182 | Jackson.... | Possible... | .... | .... | .... | .... | 15.4 | 17.4 | 15.6 | 17.4 | 5.4 | 11.2 | 16.6 | 99.0 | 4 | **291.1** | 30.0 | 2520 | 19.7 | 27.8 |
| | | | | | | | | | | | | | | | 6 | 253.4 | **30.9** | | | |
| | | | | | | | | | | | | | | | 8 | 224.2 | 28.4 | | | |
| 61 | Jo Daviess.. | Possible... | .... | .... | .... | .... | 2.0 | 6.0 | 9.4 | 26.4 | 9.0 | 27.4 | 19.4 | 99.6 | 4 | **317.7** | 11.2 | 2680 | 17.5 | 12.3 |
| | | | | | | | | | | | | | | | 6 | 297.8 | **12.2** | | | |
| | | | | | | | | | | | | | | | 8 | 287.5 | 10.9 | | | |
| 62 | Jo Daviess.. | Possible... | .... | .... | .... | .... | 23.6 | 27.0 | 18.0 | 15.0 | 2.6 | 4.8 | 8.0 | 99.0 | 4 | **220.4** | **52.2** | 1304 | .... | 47.6 |
| | | | | | | | | | | | | | | | 6 | 152.4 | 44.0 | | | |
| | | | | | | | | | | | | | | | 8 | 130.7 | 41.8 | | | |
| 63 | Jo Daviess.. | Possible (Calcium carbonate present)... | .... | .... | .... | .... | .4 | .5 | 1.0 | 4.2 | 4.2 | 69.8 | 19.0 | 99.1 | 4 | 219.2 | 2.6 | 2480 | | 4.3 |
| | | | | | | | | | | | | | | | 6 | **256.6** | 3.3 | | | |
| | | | | | | | | | | | | | | | 8 | 227.7 | **3.4** | | | |
| 2 | Kane..... | Produced.. | .... | .... | .... | 1.6 | 27.0 | 5.8 | 3.6 | 2.6 | 1.4 | 29.4 | 28.0 | 99.4 | 4 | 310.3 | 20.6 | 4600 | | 13.7 |
| | | | | | | | | | | | | | | | 6 | **362.0** | **24.1** | | | |
| | | | | | | | | | | | | | | | 8 | 337.3 | 20.4 | | | |
| 5 | Kane..... | Possible... | .... | .... | .... | 5.8 | 37.4 | 13.0 | 5.8 | 5.0 | 1.2 | 11.4 | 20.0 | 99.6 | 4 | **262.1** | **48.2** | 2304 | | 45.2 |
| | | | | | | | | | | | | | | | 6 | 257.5 | 43.2 | | | |
| | | | | | | | | | | | | | | | 8 | 245.4 | 38.6 | | | |
| 6 | Kane..... | Produced.. | .... | .... | .... | 3.0 | 31.2 | 11.4 | 4.0 | 3.6 | 1.8 | 22.8 | 21.4 | 99.2 | 4 | 228.5 | 12.1 | 3040 | 15.3 | 27.8 |
| | | | | | | | | | | | | | | | 6 | 271.8 | **20.3** | | | |
| | | | | | | | | | | | | | | | 8 | **314.2** | 15.9 | | | |
| 7 | Kane..... | Produced.. | .... | .... | .... | 1.6 | 36.7 | 16.2 | 8.0 | 6.1 | 1.2 | 13.0 | 16.6 | 99.4 | 4 | **237.9** | **58.3** | 1872 | | 43.2 |
| | | | | | | | | | | | | | | | 6 | 235.4 | 53.3 | | | |
| | | | | | | | | | | | | | | | 8 | 223.4 | 40.4 | | | |
| 8 | Kane..... | Produced.. | .... | .... | .... | 1.4 | 23.3 | 15.4 | 7.6 | 6.3 | 1.7 | 21.4 | 21.7 | 98.8 | 6 | 245.3 | 28.8 | 2704 | | 35.8 |
| | | | | | | | | | | | | | | | 8 | **288.7** | **32.6** | | | |
| | | | | | | | | | | | | | | | 10 | 281.5 | 8.7 | | | |
| 38 | Kane..... | Produced.. | .... | .02 | .04 | 4.2 | 54.4 | 9.2 | 2.5 | 1.7 | .5 | 11.1 | 15.1 | 98.76 | 4 | 194.3 | **67.7** | 1112 | 9.2 | 37.6 |
| | | | | | | | | | | | | | | | 6 | **263.3** | 62.7 | | | |
| | | | | | | | | | | | | | | | 8 | 166.5 | 44.8 | | | |
| 19 | Kendall.... | Possible?.. | .... | .... | 1.2 | 2.0 | 39.4 | 20.0 | 6.4 | 3.4 | .4 | 2.8 | 23.8 | 99.4 | 4 | **307.9** | **127.8** | 1720 | | 66.3 |
| | | | | | | | | | | | | | | | 6 | 258.6 | 96.7 | | | |
| | | | | | | | | | | | | | | | 8 | 202.2 | 53.8 | | | |
| 126 | La Salle.... | Possible... | .... | .... | .... | 37.8 | 57.2 | 2.2 | .6 | .4 | .1 | .1 | 1.2 | 99.6 | 1 | **66.9** | 503.2 | 176 | | |
| | | | | | | | | | | | | | | | 2 | 63.2 | 503.2 | | | |
| | | | | | | | | | | | | | | | 4 | 63.6 | 503.2 | | | |
| 195 | Lawrence... | Possible... | .... | .... | .... | .6 | 45.0 | 18.0 | 5.0 | 2.2 | .4 | 2.0 | 26.0 | 99.2 | 6 | **305.8** | **83.5** | 1488 | 35.5 | 53.1 |
| | | | | | | | | | | | | | | | 8 | 292.0 | 71.6 | | | |
| | | | | | | | | | | | | | | | 10 | 245.4 | 34.2 | | | |
| 172 | Madison.... | Possible... | .... | .... | .... | .... | 8.4 | 25.4 | 13.8 | 8.8 | 2.6 | 28.4 | 11.6 | 99.0 | 4 | **235.7** | 8.5 | 1672 | | 9.8 |
| | | | | | | | | | | | | | | | 6 | 209.5 | 9.1 | | | |
| | | | | | | | | | | | | | | | 8 | 188.5 | **9.2** | | | |
| 173 | Madison.... | Possible (Calcium carbonate present)... | .... | .... | .... | .2 | 8.2 | 13.0 | 8.3 | 8.7 | 3.8 | 45.0 | 12.4 | 99.6 | 4 | **267.2** | 6.5 | 2320 | | 9.2 |
| | | | | | | | | | | | | | | | 6 | 254.5 | **9.3** | | | |
| | | | | | | | | | | | | | | | 8 | 231.0 | 6.7 | | | |
| 175 | Madison.... | Possible... | .... | .... | .... | .... | 8.0 | 21.8 | 12.0 | 9.6 | 6.1 | 25.0 | 16.0 | 98.7 | 4 | **259.8** | **22.4** | (3) | | 18.7 |
| | | | | | | | | | | | | | | | 6 | 255.5 | 20.2 | | | |
| | | | | | | | | | | | | | | | 8 | 232.5 | 19.4 | | | |

[1] Bold-face figures indicate the best developed bond strength and permeability.
[2] Precise locations are given on pages 155-157.
[3] Sample No. 175 was entirely consumed in the other tests and consequently no dye-adsorption test could be made of it.

TABLE 30.—*Results of tests on Illinois molding sands*[1]—Continued

| Lab. No. | County[2] | Grade if Used | Screen Analysis | | | | | | | | | | | Water Per cent | Bond Strength | Permeability | Dye Adsorption | Per cent Loss Bond Strength at 600° F. | Base Permeability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | On 6 | On 12 | On 20 | On 40 | On 70 | On 100 | On 140 | On 200 | On 270 | Through 270 | Clay | Total | | | | | | |
| 127 | Marshall... | Possible... | .... | .... | .... | .... | 3.8 | 15.3 | 18.7 | 17.3 | 2.6 | 14.2 | 27.2 | 99.1 | 4 | ..... | 31.3 | 2080 | 8.8 | 31.2 |
| | | | | | | | | | | | | | | | 6 | 299.6 | **35.7** | | | |
| | | | | | | | | | | | | | | | 8 | **306.1** | 34.3 | | | |
| 9 | McHenry... | Produced.. | .... | .... | .... | 1.6 | 19.2 | 17.2 | 12.2 | 7.2 | 11.7 | 16.8 | 12.6 | 98.5 | 6 | 194.6 | 11.1 | 2840 | | 13.5 |
| | | | | | | | | | | | | | | | 8 | 231.6 | **17.4** | | | |
| | | | | | | | | | | | | | | | 10 | **251.1** | 15.5 | | | |
| 21 | McHenry... | Possible... | .... | .... | .... | .4 | 6.4 | 5.0 | 5.2 | 10.0 | 8.8 | 38.0 | 25.6 | 99.4 | 4 | 285.0 | **11.3** | 3680 | | 8.5 |
| | | | | | | | | | | | | | | | 6 | 290.6 | 9.6 | | | |
| | | | | | | | | | | | | | | | 8 | **297.6** | 7.6 | | | |
| 22 | McHenry... | Possible... | .... | .... | .... | .8 | 19.0 | 12.8 | 7.4 | 10.4 | 5.0 | 24.0 | 19.6 | 99.0 | 4 | ..... | ..... | 2880 | | 9.0 |
| | | | | | | | | | | | | | | | 6 | **301.0** | **18.3** | | | |
| | | | | | | | | | | | | | | | 8 | 268.6 | 15.6 | | | |
| 54 | Ogle..... | Possible?.. | .... | .... | .3 | 7.7 | 67.8 | 6.6 | 1.1 | .7 | .2 | 6.8 | 7.9 | 99.1 | 4 | **150.4** | **125.3** | 1160 | | 162.7 |
| | | | | | | | | | | | | | | | 6 | 110.5 | 98.3 | | | |
| | | | | | | | | | | | | | | | 8 | ..... | 71.6 | | | |
| 55 | Ogle..... | Possible... | .... | 1.1 | 1.8 | 4.2 | 36.2 | 17.0 | 5.4 | 3.4 | .6 | 19.1 | 10.6 | 99.4 | 4 | **253.1** | 30.6 | 1640 | 10.5 | 17.2 |
| | | | | | | | | | | | | | | | 6 | 252.7 | **37.7** | | | |
| | | | | | | | | | | | | | | | 8 | 233.6 | 27.9 | | | |
| 57 | Ogle..... | Possible... | .... | .... | .04 | 7.6 | 59.0 | 4.0 | 1.0 | .1 | .1 | 7.0 | 20.0 | 99.2 | 4 | **290.0** | **156.6** | 2176 | | 189.2 |
| | | | | | | | | | | | | | | | 6 | 265.9 | 100.3 | | | |
| | | | | | | | | | | | | | | | 8 | 278.9 | 89.5 | | | |
| 150 | Peoria..... | Possible... | .... | .... | .... | .... | .8 | 5.0 | 22.6 | 38.6 | 6.8 | 15.0 | 10.6 | 99.4 | 4 | **141.8** | **21.6** | 976 | **2.0** gain | 20.2 |
| | | | | | | | | | | | | | | | 6 | 136.9 | 20.4 | | | |
| | | | | | | | | | | | | | | | 8 | 128.0 | **21.6** | | | |
| 152 | Peoria..... | Possible (Calcium carbonate present)... | .... | .... | .... | .... | .7 | 2.6 | 11.1 | 32.6 | 10.6 | 35.8 | 5.0 | 98.4 | 4 | 127.9 | 13.4 | 904 | | 11.0 |
| | | | | | | | | | | | | | | | 6 | **140.9** | **14.9** | | | |
| | | | | | | | | | | | | | | | 8 | 140.8 | **14.9** | | | |
| 153 | Peoria..... | Possible (Calcium carbonate present) .. | .... | .... | .... | .... | 1.6 | 6.4 | 13.2 | 25.0 | 6.8 | 36.8 | 9.0 | 98.8 | 4 | 151.6 | 9.3 | 920 | 16.9 | 12.9 |
| | | | | | | | | | | | | | | | 6 | **157.4** | 9.6 | | | |
| | | | | | | | | | | | | | | | 8 | 147.1 | **9.8** | | | |
| 154 | Peoria..... | Possible... | .... | .... | .6 | 22.2 | 55.3 | 3.8 | 1.6 | 1.8 | .6 | 1.4 | 11.6 | 99.0 | 4 | 280.5 | 216.0 | 2070 | | 245.0 |
| | | | | | | | | | | | | | | | 6 | **284.9** | **251.6** | | | |
| | | | | | | | | | | | | | | | 8 | 185.7 | 106.6 | | | |
| 184 | Pope..... | Possible... | .... | .... | .... | .1 | 6.2 | 9.0 | 8.0 | 9.6 | 4.6 | 34.6 | 27.2 | 99.3 | 4 | 138.4 | 3.6 | 560 | | 7.5 |
| | | | | | | | | | | | | | | | 6 | 141.5 | 3.9 | | | |
| | | | | | | | | | | | | | | | 8 | 168.0 | 5.4 | | | |
| | | | | | | | | | | | | | | | 10 | **183.8** | **6.8** | | | |
| 185 | Pope..... | Possible... | .... | .... | .... | .... | 7.8 | 11.2 | 6.8 | 8.4 | 22.4 | 21.8 | 20.2 | 98.6 | 8 | 268.9 | 12.7 | 1920 | | 6.7 |
| | | | | | | | | | | | | | | | 10 | 290.2 | 13.7 | | | |
| | | | | | | | | | | | | | | | 11 | **300.0** | **14.4** | | | |
| 186 | Pope..... | Possible... | .... | .... | .... | .... | 6.4 | 10.6 | 6.8 | 7.2 | 2.6 | 24.4 | 40.6 | 98.6 | 6 | 181.2 | 3.9 | 1472 | 4.8 | 6.5 |
| | | | | | | | | | | | | | | | 8 | 207.9 | 7.4 | | | |
| | | | | | | | | | | | | | | | 10 | 219.2 | 9.4 | | | |
| | | | | | | | | | | | | | | | 12 | **220.9** | **10.2** | | | |
| 187 | Pope..... | Possible... | .... | 3.0 | 15.4 | 28.4 | 18.2 | 6.8 | 4.4 | 4.0 | 1.0 | 3.6 | 14.4 | 99.2 | 4 | **273.8** | **208.8** | 1120 | | 113.4 |
| | | | | | | | | | | | | | | | 6 | 249.6 | 156.6 | | | |
| | | | | | | | | | | | | | | | 8 | 233.7 | 104.4 | | | |
| 188 | Pope..... | Possible... | .... | .... | .... | .... | 47.0 | 18.4 | 5.2 | 2.0 | .2 | 4.0 | 22.6 | 99.4 | 6 | **282.2** | **69.6** | 1760 | | 60.5 |
| | | | | | | | | | | | | | | | 8 | 270.0 | 62.6 | | | |
| | | | | | | | | | | | | | | | 10 | 242.3 | 41.2 | | | |
| 189 | Pope..... | Possible... | .... | .... | .... | .2 | 1.4 | .6 | 1.8 | .5 | 1.4 | 54.7 | 38.4 | 99.0 | 4 | 158.2 | 1.1 | 1008 | | 4.3 |
| | | | | | | | | | | | | | | | 6 | 212.0 | 1.5 | | | |
| | | | | | | | | | | | | | | | 8 | **214.9** | **1.7** | | | |

[1] Bold-face figures indicate the best developed bond strength and permeability.
[2] Precise locations are given on pages 157-160.

TABLE 30.—*Results of tests on Illinois molding sands*[1]—Continued

| Lab. No. | County[2] | Grade if Used | Screen Analysis | | | | | | | | | | | | Water Per cent | Bond Strength | Permeability | Dye Adsorption | Per cent Loss Bond Strength at 600° F. | Base Permeability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | On 6 | On 12 | On 20 | On 40 | On 70 | On 100 | On 140 | On 200 | On 270 | Through 270 | Clay | Total | | | | | | |
| 183 | Pulaski..... | No value.. | .... | .... | .... | .... | .6 | 2.8 | 23.0 | 54.0 | 5.4 | 3.4 | 10.0 | 99.2 | 4 | **188.0** | **41.8** | | | |
| | | | | | | | | | | | | | | | 6 | 143.9 | 36.8 | 1360 | 21.5 | 40.1 |
| | | | | | | | | | | | | | | | 8 | 116.4 | 33.4 | | | |
| 181 | Randolph... | Possible... | .... | .... | .... | 1.4 | 1.0 | 1.2 | 3.4 | 15.0 | 7.8 | 43.2 | 26.1 | 99.1 | 6 | 199.1 | 6.6 | | | |
| | | | | | | | | | | | | | | | 8 | **241.4** | 7.3 | 2208 | | 10.3 |
| | | | | | | | | | | | | | | | 10 | 226.3 | **9.6** | | | |
| 78 | Rock Island. | Produced.. | .... | .... | .... | .... | 5.1 | 9.4 | 18.5 | 22.8 | 9.6 | 26.0 | 7.4 | 98.8 | 4 | 190.8 | **10.3** | | | |
| | | | | | | | | | | | | | | | 6 | 197.2 | **10.3** | 2976 | 9.3 | 17.0 |
| | | | | | | | | | | | | | | | 8 | **199.1** | 10.0 | | | |
| 79 | Rock Island. | Possible... | .... | .... | .... | 2.4 | 8.8 | 7.6 | 11.4 | 17.8 | 5.6 | 25.4 | 20.0 | 99.0 | 4 | ..... | 14.3 | | | |
| | | | | | | | | | | | | | | | 6 | 203.7 | **14.5** | 2520 | | 12.0 |
| | | | | | | | | | | | | | | | 8 | **213.4** | 11.0 | | | |
| 84 | Rock Island. | "Black-hawk" (Calcium carbonate present)... | .... | .1 | .04 | 1.3 | 7.5 | 4.2 | 4.8 | 11.0 | 7.7 | 57.8 | 4.7 | 99.14 | 4 | 151.9 | 8.0 | | | |
| | | | | | | | | | | | | | | | 6 | 156.3 | **8.4** | 1008 | | 10.3 |
| | | | | | | | | | | | | | | | 8 | **160.7** | **8.4** | | | |
| 85 | Rock Island. | "Mud Island"... | .... | .1 | .3 | .3 | 2.7 | 13.5 | 21.9 | 17.6 | 3.8 | 24.2 | 14.8 | 99.2 | 4 | 241.8 | **18.1** | | | |
| | | | | | | | | | | | | | | | 6 | **270.4** | 16.9 | 2800 | 14.5 | 15.7 |
| | | | | | | | | | | | | | | | 8 | 255.0 | 15.5 | | | |
| 102 | Rock Island. | "Black-hawk" (Calcium carbonate present)... | .... | .... | .... | .... | .6 | .8 | 1.2 | 4.2 | 4.4 | 78.8 | 9.7 | 99.7 | 4 | 181.3 | 4.1 | | | |
| | | | | | | | | | | | | | | | 6 | **197.8** | 4.4 | 2176 | **1.9** | 6.5 |
| | | | | | | | | | | | | | | | 8 | 173.8 | **4.7** | | gain | |
| 105 | Rock Island. | Possible... | .... | .... | .... | .02 | 1.1 | 16.0 | 27.0 | 22.9 | 4.0 | 16.7 | 11.2 | 98.92 | 4 | **208.6** | **20.2** | | | |
| | | | | | | | | | | | | | | | 6 | 202.0 | 17.4 | 2240 | | 20.5 |
| | | | | | | | | | | | | | | | 8 | 183.3 | 15.9 | | | |
| 106 | Rock Island. | Possible... | .... | 1.2 | 5.6 | 20.0 | 35.4 | 7.4 | 3.4 | 1.8 | .8 | 6.2 | 17.6 | 99.4 | 4 | 209.9 | 32.2 | | | |
| | | | | | | | | | | | | | | | 6 | **232.3** | 38.6 | 1072 | | 50.1 |
| | | | | | | | | | | | | | | | 8 | 215.8 | **45.6** | | | |
| 110 | Rock Island. | Possible... | .... | .... | .... | 1.2 | 9.8 | 7.1 | 7.4 | 11.8 | 19.8 | 33.8 | 8.2 | 99.1 | 4 | 236.4 | 4.4 | | | |
| | | | | | | | | | | | | | | | 6 | **271.4** | 4.6 | 2240 | 7.7 | 8.4 |
| | | | | | | | | | | | | | | | 8 | 261.8 | **4.7** | | | |
| 156 | Sangamon.. | Possible... | .... | .... | .... | 5.0 | 47.0 | 17.6 | 7.0 | 4.4 | .4 | 1.4 | 16.2 | 99.0 | 4 | **321.3** | **147.7** | | | |
| | | | | | | | | | | | | | | | 6 | 301.3 | 104.4 | 2080 | | 92.4 |
| | | | | | | | | | | | | | | | 8 | 243.6 | 92.8 | | | |
| 180 | St. Clair.... | Possible (Calcium carbonate present) | .... | .... | .... | .... | .2 | .2 | .2 | .8 | .8 | 89.0 | 8.2 | 99.4 | 4 | 145.0 | 4.3 | | | |
| | | | | | | | | | | | | | | | 6 | **186.0** | 4.5 | 1408 | 5.0 | 5.1 |
| | | | | | | | | | | | | | | | 8 | 172.6 | **4.7** | | | |
| 196 | Shelby..... | Possible... | .... | .... | .... | 11.4 | 48.8 | 7.4 | 3.2 | 2.8 | .6 | .8 | 24.6 | 99.6 | 6 | 361.6 | **188.3** | | | |
| | | | | | | | | | | | | | | | 8 | 358.2 | 98.6 | 3104 | 25.0 | 232.0 |
| | | | | | | | | | | | | | | | 10 | **370.2** | 124.0 | | | |
| 155 | Tazewell.. | Possible... | .... | .... | .... | .6 | 15.2 | 19.0 | 15.2 | 9.2 | 1.6 | 13.8 | 24.6 | 99.2 | 6 | 238.7 | 22.7 | | | |
| | | | | | | | | | | | | | | | 8 | **252.4** | **26.1** | 1888 | 4.1 | 31.7 |
| | | | | | | | | | | | | | | | 10 | 215.9 | 19.2 | | | |
| 192 | White..... | Possible... | .... | .... | .... | .... | 24.6 | 33.4 | 12.2 | 5.4 | .6 | 4.0 | 19.0 | 99.2 | 4 | **306.9** | **70.2** | | | |
| | | | | | | | | | | | | | | | 6 | 284.3 | 63.9 | 2240 | 21.8 | 33.3 |
| | | | | | | | | | | | | | | | 8 | 254.4 | 45.8 | | | |
| 193 | White..... | Possible... | .... | .... | .... | .... | 23.2 | 23.2 | 18.2 | 15.2 | 2.4 | 3.8 | 11.0 | 97.0 | 4 | **247.7** | **46.8** | | | |
| | | | | | | | | | | | | | | | 6 | 210.6 | 39.3 | 1440 | | 43.9 |
| | | | | | | | | | | | | | | | 8 | 151.9 | 40.2 | | | |
| 194 | White..... | Possible... | .... | .... | .... | .... | 7.0 | 22.0 | 23.0 | 21.4 | 4.4 | 5.0 | 16.6 | 99.4 | 4 | 315.9 | **42.4** | | | |
| | | | | | | | | | | | | | | | 6 | **323.3** | 41.2 | 2208 | 14.5 | 31.3 |
| | | | | | | | | | | | | | | | 8 | 283.7 | 37.9 | | | |

[1] Bold-face figures indicate the best developed bond strength and permeability.
[2] Precise locations are given on pages 159-162.

TABLE 30.—*Results of tests on Illinois molding sands*[1]—Continued

| Lab. No. | County[2] | Grade if Used | Screen Analysis | | | | | | | | | | | | Water Per cent | Bond Strength | Permeability | Dye Adsorption | Per cent Loss Bond Strength at 600° F. | Base Permeability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | On 6 | On 12 | On 20 | On 40 | On 70 | On 100 | On 140 | On 200 | On 270 | Through 270 | Clay | Total | | | | | | |
| 65 | Whiteside... | Possible (Calcium carbonate present)... | .... | .... | .... | .... | 11.0 | 18.0 | 13.4 | 14.0 | 5.4 | 30.8 | 6.8 | 99.4 | 4 | **154.1** | 12.2 | | | |
| | | | | | | | | | | | | | | | 6 | 138.3 | 12.9 | 1024 | | 16.4 |
| | | | | | | | | | | | | | | | 8 | 143.3 | **13.4** | | | |
| 66 | Whiteside... | Possible... (Calcium carbonate present)... | .... | .... | .... | .... | 11.0 | 11.8 | 8.8 | 13.0 | 7.0 | 39.2 | 8.2 | 99.2 | 4 | **247.4** | 8.1 | | | |
| | | | | | | | | | | | | | | | 6 | 172.2 | 9.0 | 1240 | 32.2 | 13.6 |
| | | | | | | | | | | | | | | | 8 | 154.2 | **10.0** | | | |
| 68 | Whiteside... | Possible... | .... | .... | .... | .... | 3.9 | 13.0 | 12.8 | 23.8 | 8.2 | 26.0 | 12.2 | 99.9 | 4 | 275.6 | **15.3** | | | |
| | | | | | | | | | | | | | | | 6 | **322.9** | 14.7 | 2680 | | 14.9 |
| | | | | | | | | | | | | | | | 8 | 302.4 | 13.6 | | | |
| 69 | Whiteside... | Possible... | .... | .... | .... | .... | 2.2 | 10.8 | 17.0 | 25.0 | 8.2 | 20.6 | 15.4 | 99.2 | 4 | **245.0** | 13.7 | | | |
| | | | | | | | | | | | | | | | 6 | 222.6 | **14.1** | 1504 | | 15.5 |
| | | | | | | | | | | | | | | | 8 | 196.1 | 13.9 | | | |
| 11 | Will..... | Produced.. | .... | .... | .... | .6 | 19.2 | 19.0 | 13.2 | 17.2 | 6.2 | 12.2 | 11.2 | 98.8 | 4 | **241.9** | **32.2** | | | |
| | | | | | | | | | | | | | | | 6 | 212.2 | 28.1 | 1556 | | 27.9 |
| | | | | | | | | | | | | | | | 8 | 165.0 | 23.4 | | | |
| 12 | Will..... | Produced.. | .... | .... | .... | .8 | 19.0 | 16.0 | 11.9 | 15.6 | 5.2 | 11.6 | 19.0 | 99.1 | 4 | 162.1 | 21.5 | | | |
| | | | | | | | | | | | | | | | 6 | **166.2** | **23.4** | 1072 | 13.9 | 14.1 |
| | | | | | | | | | | | | | | | 8 | 136.9 | 22.0 | | | |
| 13 | Will. ..... | Produced.. | .... | .... | .... | .... | 12.8 | 14.2 | 15.8 | 10.4 | 8.4 | 28.8 | 9.0 | 99.4 | 4 | 131.7 | 11.0 | | | |
| | | | | | | | | | | | | | | | 6 | **133.7** | 12.6 | 304 | | 14.4 |
| | | | | | | | | | | | | | | | 8 | 127.3 | **13.6** | | | |
| 15 | Will..... | Possible... | .... | .... | .... | .7 | 51.5 | 23.3 | 6.4 | 4.2 | .5 | .6 | 11.8 | 99.0 | 4 | **267.4** | **139.2** | | | |
| | | | | | | | | | | | | | | | 6 | 200.2 | 96.4 | 1744 | | 99.9 |
| | | | | | | | | | | | | | | | 8 | 124.4 | 67.8 | | | |
| 39 | Will..... | Possible... | .... | .2 | 1.8 | 6.4 | 38.0 | 13.4 | 6.6 | 4.6 | 1.0 | 7.0 | 20.0 | 99.0 | 4 | ..... | ..... | | | |
| | | | | | | | | | | | | | | | 6 | **253.2** | **72.4** | 1904 | | 88.6 |
| | | | | | | | | | | | | | | | 8 | 248.0 | 51.2 | | | |
| 40 | Will..... | Possible... | .... | .... | .4 | 4.4 | 33.0 | 16.0 | 7.0 | 5.4 | 7.0 | 6.8 | 19.0 | 99.0 | 4 | 243.9 | **79.8** | | | |
| | | | | | | | | | | | | | | | 6 | **270.1** | 73.9 | 2080 | 5.1 | 87.0 |
| | | | | | | | | | | | | | | | 8 | 237.4 | 36.8 | | | |
| 46 | Winnebago.. | Possible... | .... | .... | .... | .4 | 25.6 | 27.6 | 8.8 | 7.0 | .8 | 13.0 | 16.8 | 99.2 | 4 | **319.0** | **50.1** | | | |
| | | | | | | | | | | | | | | | 6 | 305.0 | 41.8 | 2504 | | 52.6 |
| | | | | | | | | | | | | | | | 8 | 299.5 | 33.9 | | | |
| 47 | Winnebago.. | Possible... | .... | .... | .... | .3 | 29.0 | 17.0 | 8.0 | 7.0 | 1.6 | 12.8 | 22.8 | 98.5 | 6 | 308.6 | 14.0 | | | |
| | | | | | | | | | | | | | | | 8 | 316.7 | 16.2 | 4272 | | 36.9 |
| | | | | | | | | | | | | | | | 10 | **338.4** | **17.9** | | | |
| 48 | Winnebago.. | Possible... | .... | .... | .... | .2 | 10.8 | 8.2 | 5.4 | 4.6 | 2.4 | 40.2 | 27.6 | 99.4 | 4 | ..... | 6.0 | | | |
| | | | | | | | | | | | | | | | 6 | 177.6 | 9.4 | 840 | | 13.2 |
| | | | | | | | | | | | | | | | 8 | **184.3** | **10.6** | | | |
| 49 | Winnebago.. | Possible ... | .... | .... | .... | .6 | 12.4 | 11.0 | 6.8 | 5.8 | 2.7 | 39.6 | 20.4 | 99.3 | 4 | 261.5 | 7.9 | | | |
| | | | | | | | | | | | | | | | 6 | 271.5 | 14.2 | 3440 | | 14.1 |
| | | | | | | | | | | | | | | | 8 | **289.4** | **15.5** | | | |
| 50 | Winnebago.. | Possible (Calcium carbonate present) | .... | .... | .... | .... | 3.0 | 2.8 | 2.4 | 5.8 | 5.0 | 69.4 | 11.0 | 99.4 | 4 | **258.0** | **4.4** | | | |
| | | | | | | | | | | | | | | | 6 | 243.3 | 4.2 | 2480 | | 5.1 |
| | | | | | | | | | | | | | | | 8 | 231.9 | 3.9 | | | |

[1] Bold-face figures indicate the best developed bond strength and permeability.
[2] Precise locations are given on pages 161-162.

TABLE 31.—*Results of tests on "imported" sands used in Illinois*[1]

| Lab. No. | Location[2] | Grade if Used | Screen Analysis | | | | | | | | | | | | Water Per cent | Bond Strength | Permeability | Dye Adsorption | Per cent Loss Bond Strength at 600° F. | Base Permeability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | On 6 | On 12 | On 20 | On 40 | On 70 | On 100 | On 140 | On 200 | On 270 | Through 270 | Clay | Total | | | | | | |
| 103 | Albany, N. Y. | Produced.. | .... | .... | .... | .5 | 6.7 | 7.4 | 13.9 | 21.5 | 7.5 | 22.1 | 19.6 | 99.2 | 4<br>6<br>8 | 145.3<br>**171.0**<br>148.4 | 8.9<br>13.3<br>**13.8** | 240 | 8.9 | 15.2 |
| 104 | Albany, N. Y. | Produced.. | .... | .... | .... | .... | 1.5 | 4.9 | 8.8 | 21.4 | 13.7 | 37.4 | 11.2 | 98.9 | 4<br>6<br>8 | .....<br>**164.8**<br>153.6 | 10.0<br>11.6<br>**12.3** | 500 | **2.6**<br>gain | 9.6 |
| 160 | Albany, N. Y. | "No. 1"... | .... | .... | .... | .2 | 1.3 | 2.9 | 9.5 | 29.0 | 15.9 | 34.4 | 5.9 | 99.1 | 4<br>6<br>8 | 140.3<br>144.2<br>**146.0** | **15.5**<br>13.7<br>14.2 | 320 | | 14.9 |
| 25 | Bauman, Ind. | Produced.. | .... | .... | .... | .... | .06 | .04 | .02 | .04 | .04 | 72.8 | 24.8 | 97.8 | 6<br>8<br>10 | 240.9<br>**263.7**<br>247.6 | 2.0<br>2.2<br>**2.8** | 1776 | 6.2 | 3.1 |
| 30 | Bauman, Ind. | Produced.. | .... | .02 | .02 | .04 | .4 | .7 | 1.3 | 5.5 | 4.9 | 70.2 | 15.2 | 98.28 | 4<br>6<br>8 | 165.3<br>202.2<br>**207.6** | 2.8<br>3.7<br>**4.2** | 1080 | 2.3 | 8.9 |
| 24 | Beloit, Wis.. | Produced.. | .... | .... | .04 | 2.6 | 41.3 | 16.9 | 6.6 | 3.9 | .1 | 13.4 | 13.0 | 97.84 | 4<br>6<br>8 | **233.2**<br>220.2<br>171.0 | **45.7**<br>34.8<br>18.3 | 1776 | | 40.9 |
| 35 | Beloit, Wis.. | "North-western".. | .... | .06 | .1 | 1.1 | 19.5 | 8.9 | 4.3 | 3.0 | 1.3 | 33.2 | 28.2 | 99.66 | 4<br>6<br>8 | 264.9<br>270.8<br>**303.7** | 17.3<br>16.3<br>**30.6** | 3480 | | 11.1 |
| 27 | Conneaut, Ohio | "Nash" | .... | .4 | .3 | .5 | 3.9 | 8.0 | 26.1 | 24.8 | 3.7 | 20.8 | 10.1 | 98.6 | 4<br>6<br>8 | .....<br>**151.1**<br>147.8 | 11.7<br>16.2<br>**19.0** | 840 | 5.4 | 16.1 |
| 28 | Bauman, Ind Conneaut, Ohio | Foundry Mix.... | .... | .02 | .1 | .2 | 1.4 | 3.5 | 10.8 | 9.1 | 1.9 | 59.3 | 12.6 | 98.92 | 4<br>6<br>8 | .....<br>168.5<br>**177.2** | 3.9<br>4.6<br>**5.3** | 912 | | 5.3 |
| 91 | Conneaut, Ohio..... | Produced.. | .... | .... | .... | .04 | 1.2 | 2.6 | 4.4 | 11.1 | 6.4 | 60.8 | 13.0 | 99.54 | 4<br>6<br>8 | .....<br>**254.2**<br>228.1 | .....<br>**7.7**<br>7.3 | 480 | | 6.2 |
| 34 | Newport, Ky..... | "Dyeton" | .... | .06 | .... | .04 | .07 | 2.2 | 2.8 | 7.0 | 5.6 | 59.0 | 21.3 | 98.7 | 4<br>6<br>8 | 188.4<br>204.0<br>**233.8** | 3.3<br>4.0<br>**4.5** | 1320 | | 7.2 |
| 33 | Newcastle, Ind. | "Bradford" | 11.7 | 1.9 | 5.0 | 3.4 | 18.6 | 7.8 | 5.6 | 5.3 | 1.4 | 17.7 | 20.7 | 99.1 | 4<br>6<br>8 | 294.2<br>301.7<br>**316.2** | 12.5<br>16.5<br>**30.7** | 1640 | | 35.4 |
| 36 | Newcastle, Ind. | "Bradford" | 2.6 | 2.2 | 3.9 | 8.7 | 26.0 | 7.9 | 4.8 | 4.6 | 1.6 | 16.8 | 19.4 | 98.5 | 4<br>6<br>8 | .....<br>330.3<br>**351.9** | 44.8<br>58.3<br>**64.3** | 1408 | 37.3 | 75.0 |
| 198 | Ridgeway, Pa. | Produced.. | .... | .... | .... | 18.0 | 50.0 | 6.0 | 2.6 | 3.0 | .4 | 7.4 | 12.0 | 99.4 | 4<br>6<br>8 | 149.0<br>151.7<br>**165.6** | 25.5<br>52.4<br>**61.9** | 440 | 11.6 | 23.0 |
| 29 | Zanesville, Ohio | Produced.. | .... | .6 | 1.9 | 9.8 | 49.8 | 8.6 | 3.0 | 1.1 | 2.4 | 11.4 | 11.2 | 99.8 | 4<br>6<br>8 | **231.3**<br>197.4<br>135.8 | **77.5**<br>63.2<br>35.1 | 880 | 33.3 | 142.4 |
| 32 | Zanesville, Ohio | Produced.. | .... | .7 | .6 | 1.9 | 18.4 | 10.7 | 6.7 | 5.7 | 2.7 | 35.6 | 16.1 | 99.1 | 4<br>6<br>8<br>10 | 145.4<br>166.7<br>202.1<br>**220.4** | **20.4**<br>15.9<br>11.1<br>9.7 | 920 | | 16.1 |

[1] Bold-face figures indicate the best developed bond strength and permeability.
[2] For further information regarding location, see pages 162 and 163.

TABLE 32.—*Classification of undeveloped molding sand deposits of Illinois.*

| Lab.[1] No. | County | Location | Distance from shipping point | Kind of sand | Estimated extent *Tons* | Class |
|---|---|---|---|---|---|---|
| 43 | Boone | N.E. ¼ sec. 7, T. 45 N., R. 4 E. | 3 mi. south of Capron Station, Chicago and Northwestern Railroad. | Medium gray iron sand. | 20,000–40,000 | B |
| 147 | Cass | N.E. ¼ N.W. ¼ sec. 27, T. 18 N., R. 11 W. | ⅛ mi. east of Bluff Springs siding, Chicago, Burlington and Quincy Railroad. | Light gray iron sand. | 14,000–35,000 | A |
| 10 | Cook | Henry Louis farm, N.E. ¼ S.W. ¼ sec. 9, T. 42 N., R. 9 E. | 5 mi. southwest of Barrington. | Medium and heavy gray iron sand. | 12,000–20,000 | B |
| 161, 162 | Fayette | State Prison farm, S.W. ¼ N.W. ¼ sec. 32, T. 7 N., R. 1 E. | Adjoins Illinois Central Railroad siding. | Heavy gray iron sand. | 50,000–200,000 | A |
| 190, 191 | Gallatin | S. ½ sec. 21, T. 9 S., R. 9 E. | 1 mi. east of Junction sidings of the Louisville and Nashville and the Baltimore and Ohio railroads. | Medium gray iron sand. | 120,000–700,000 | A |
| 93, 94, 95 | Henry | S.W. ¼ S.W. ¼ sec. 11, T. 17 N., R. 2 E. | ½ mi. south of Colona siding of Chicago, Rock Island and Pacific Railroad. | Medium gray iron sand. | 18,000–30,000 | A |
| 111 | Henry | S.W. ¼ sec. 10, T. 17 N., R. 2 E. | 3 mi. east of Green River siding of Chicago, Rock Island and Pacific Railroad. Adjoins tracks of this railroad. | Light gray iron sand. | 30,000–240,000 | A |
| 182 | Jackson | S.W. ¼ N.E. ¼ sec. 16, T. 9 S., R. 3 W. | Adjoins Sand Ridge siding of Illinois Central Railroad. | Medium gray iron sand. | 60,000–400,000 | A |
| 63 | Jo Daviess | N.W. ¼ N.W. ¼ sec. 22, T. 27 N., R. 1 E. | 1 mi. southwest of Rice Station, Chicago Great Western Railroad. | Loess. | 200,000–1,000,000 | A |
| 19 | Kendall | N.W. ¼ N.E. ¼ sec. 34, T. 37 N., R. 6 E. | 1¼ mi. south of Plano siding, Chicago, Burlington and Quincy Railroad. | Medium gray iron sand. | 2,000–20,000 | B |
| ..... | La Salle | S.E. ¼ S.E. ¼ sec. 4, T. 34 N., R. 4 E. | 1 mi. northeast of Wedron. | Medium gray iron sand. | 5,000–10,000 | B |
| 195 | Lawrence | N.W. ¼ S.W. ¼ sec. 3, T. 3 N., R. 11 W. | 1¼ mi. east of Lawrenceville siding of Baltimore and Ohio Railroad. Adjoins tracks of this railroad. | Medium gray iron sand. | 30,000–120,000 | A |
| ..... | Lawrence | S.W. ¼ S.W. ¼ sec. 17, T. 4 N., R. 11 W. | 2 mi. north of Lawrenceville siding of Baltimore and Ohio Railroad. | Medium gray iron sand. | 10,000–20,000 | B |
| ..... | Lee | S.W. ¼ N.E. ¼ sec. 24, T. 22 N., R. 11 E. | 3½ mi. east of Ashton. Adjoins Chicago and Northwestern Railroad. | Light gray iron sand. | 20,000 | A |
| 127 | Marshall | Peter Hank, owner, S.W. ¼ N.E. ¼ sec. 4, T. 30 N., R. 2 W. | 2 mi. east of Henry siding, Chicago, Rock Island and Pacific Railroad. | Light gray iron sand. | 3,000–5,000 | B |
| 21, 22 | McHenry | Consumer's Gravel Co., S.W. ¼ S.E. ¼ sec. 16, T. 43 N., R. 8 E. | Adjoins spur of Chicago and Northwestern Railroad. | Medium gray iron sand. | 80,000–200,000 | A |
| ..... | McHenry | N.E. ¼ S.W. ¼ sec. 14, T. 45 N., R. 8 E. | 2 mi. north of McHenry siding, Chicago and Northwestern Railroad. | Medium gray iron sand. | 5,000–10,000 | B |

[1]See Table 30 and and the descriptions of samples immediately preceding it for results of tests and further details descriptive of the deposits. See also the County Reports.

TABLE 32.—*Classification of undeveloped molding sand deposits of Illinois*—Continued.

| Lab.[1] No. | County | Location | Distance from shipping point | Kind of sand | Estimated extent *Tons* | Class |
|---|---|---|---|---|---|---|
| 55 | Ogle | W. ½ S.W. ¼ sec. 7, T. 23 N., R. 11 E. | ⅛ mi. east of Honey Creek siding, Chicago, Burlington and Quincy Railroad. | Medium gray iron sand. | 60,000–120,000 | A |
| 54 | Ogle | S. ½ S.E. ¼ sec. 5, T. 25 N., R. 11 E. | 1 mi. southwest of Byron siding, Chicago Great Western Railroad. | Medium gray iron sand. | 5,000–30,000 | B |
| 57 | Ogle | W. cen. W. ½ sec. 31, T. 23 N., R. 8 E. | 5 mi. south of Oregon siding, Chicago, Burlington and Quincy Railroad. | Heavy gray iron sand. | 10,000–60,000 | B |
| 150, 152 | Peoria | N.W. ¼ S.E. ¼ sec. 21, T. 9 N., R. 7 E. | 2½ mi. east of Edwards siding, Chicago, Burlington and Quincy Railroad. ⅛ mi. north of right-of-way of same railroad. | Light gray iron sand. | 100,000–200,000 | A |
| 153 | Peoria | N.W. ¼ S.W. ¼ sec. 27, T. 9 N., R. 7 E. | 2 mi. west of Pottstown siding, Chicago, Burlington and Quincy Railroad. ½ mi. south of right-of-way of same railroad. | Light gray iron sand. | 60,000–200,000 | A |
| 184, 185, 186, 189 | Pope | N.W. ¼ S.E. ¼ sec. 2, T. 14 S., R. 5 E. | 1 mi. south of Brownfield siding, Illinois Central Railroad. | Light gray iron sand. | 180,000–1,200,000 | A |
| 188 | Pope | N.W. ¼ S.E. ¼ sec. 4, T. 14 S., R. 6 E. | Adjoins Homberg siding, Illinois Central Railroad. | Medium gray iron sand. | 5,000 | A |
| 187 | Pope | N.W. ¼ N.E. ¼ sec. 15, T. 14 S., R. 6 E. | 2½ mi. south of Homberg siding, Illinois Central Railroad. | Heavy gray iron sand. | 5,000 | B |
| 181 | Randolph | S.W. ¼ N.E. ¼ sec. 28, T. 7 S., R. 6 W. | Adjoins Clores siding, Wabash, Chester and Western Railroad. | Light gray iron sand. | 20,000–50,000 | A |
| 156 | Sangamon | S.W. ¼ N.E. ¼ sec. 4, T. 17 N., R. 4 W. | ¼ mi. northwest of Spaulding siding, Illinois Central Railroad. | Medium gray iron sand. | 10,000–15,000 | A |
| 196 | Shelby | Forrest Howe, owner. T. 10 N., R. 4 W. | 2½ mi. northwest of Fancher, ½ mi. east of Kaskaskia River. | Heavy gray iron sand. | 12,000 | B |
| 155 | Tazewell | N.E. ¼ S.W. ¼ sec. 13, T. 25 N., R. 5 W. | 3 mi. north of Pekin, ¼ mi. east of Chicago, Peoria, and St. Louis Railroad right-of-way. | Medium gray iron sand. | 200,000–500,000 | A |
| 194 | White | S. ½ sec. 29, T. 3 S., R. 11 E. | 1¼ mi. south of Grayville siding, Big Four Railroad. Adjoins right-of-way of same road. | Medium gray iron sand. | 20,000–240,000 | A |
| 192 | White | S.E. ¼ S.W. ¼ sec. 8, T. 5 S., R. 10 E. | 1½ mi. east of Carmi siding, Big Four Railroad. | Medium gray iron sand. | 42,000 | B |
| 193 | White | N.W. ¼ S.E. ¼ sec. 11, T. 5 S., R. 10 E. | 3½ mi. southeast of Simpson siding, Big Four Railroad. | Medium gray iron sand. | 40,000–100,000 | B |
| 68, 69 | Whiteside | Harry Hanzinga, owner. N.E. ¼ N.W. ¼ sec. 32, T. 21 N., R. 4 E. | 3 mi. north of Fenton siding, Chicago, Burlington and Quincy Railroad. Adjoins right-of-way of same road. | Medium gray iron sand. | 40,000–80,000 | A |

[1]See Table 30 and the descriptions of samples immediately preceding it for results of tests and further details descriptive of the deposits. See also the County Reports.

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